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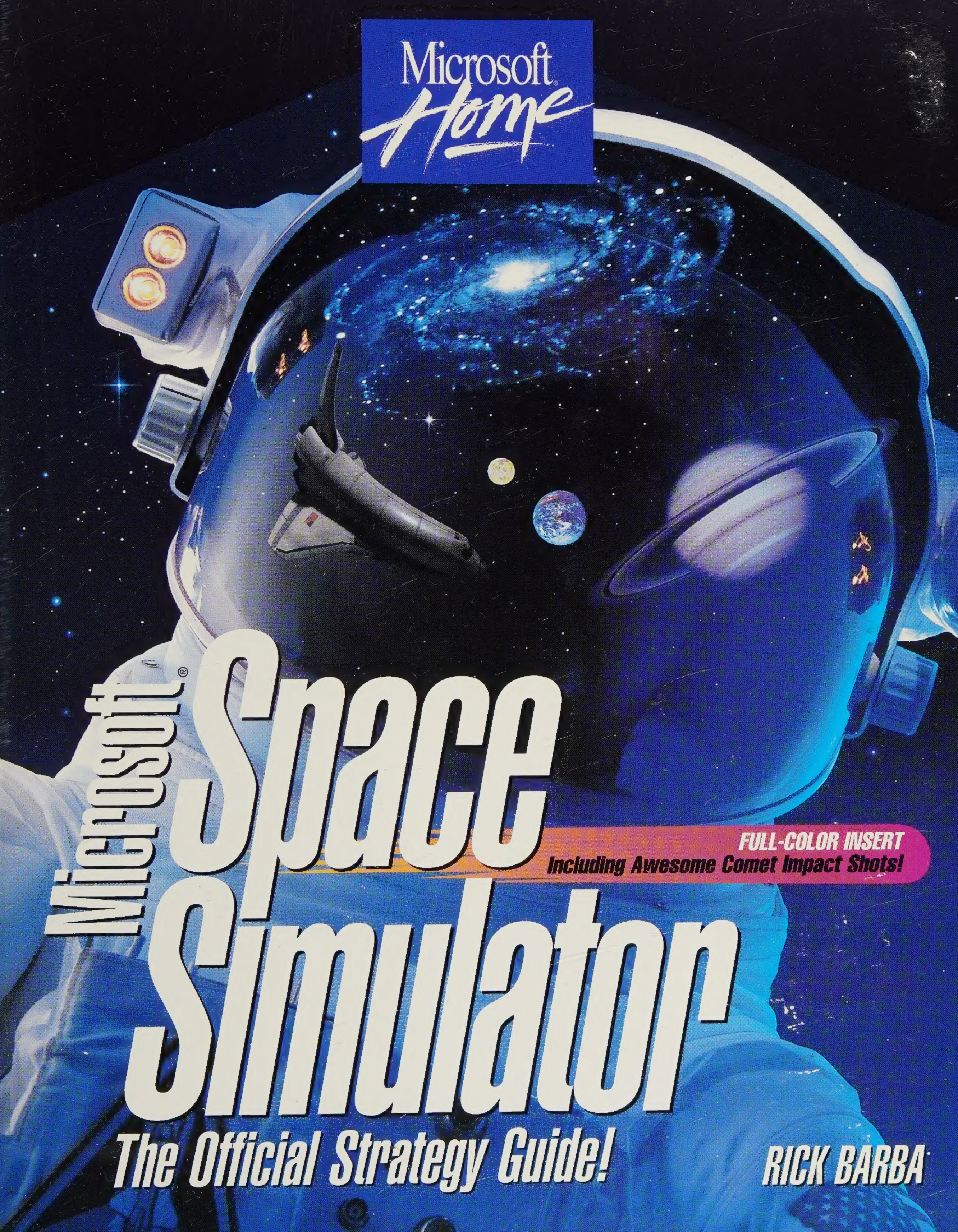

Microsoft® Space Simulator

The Official Strategy Guide!

FULL-COLOR INSERT
Including Awesome Comet Impact Shots!

RICK BARBA

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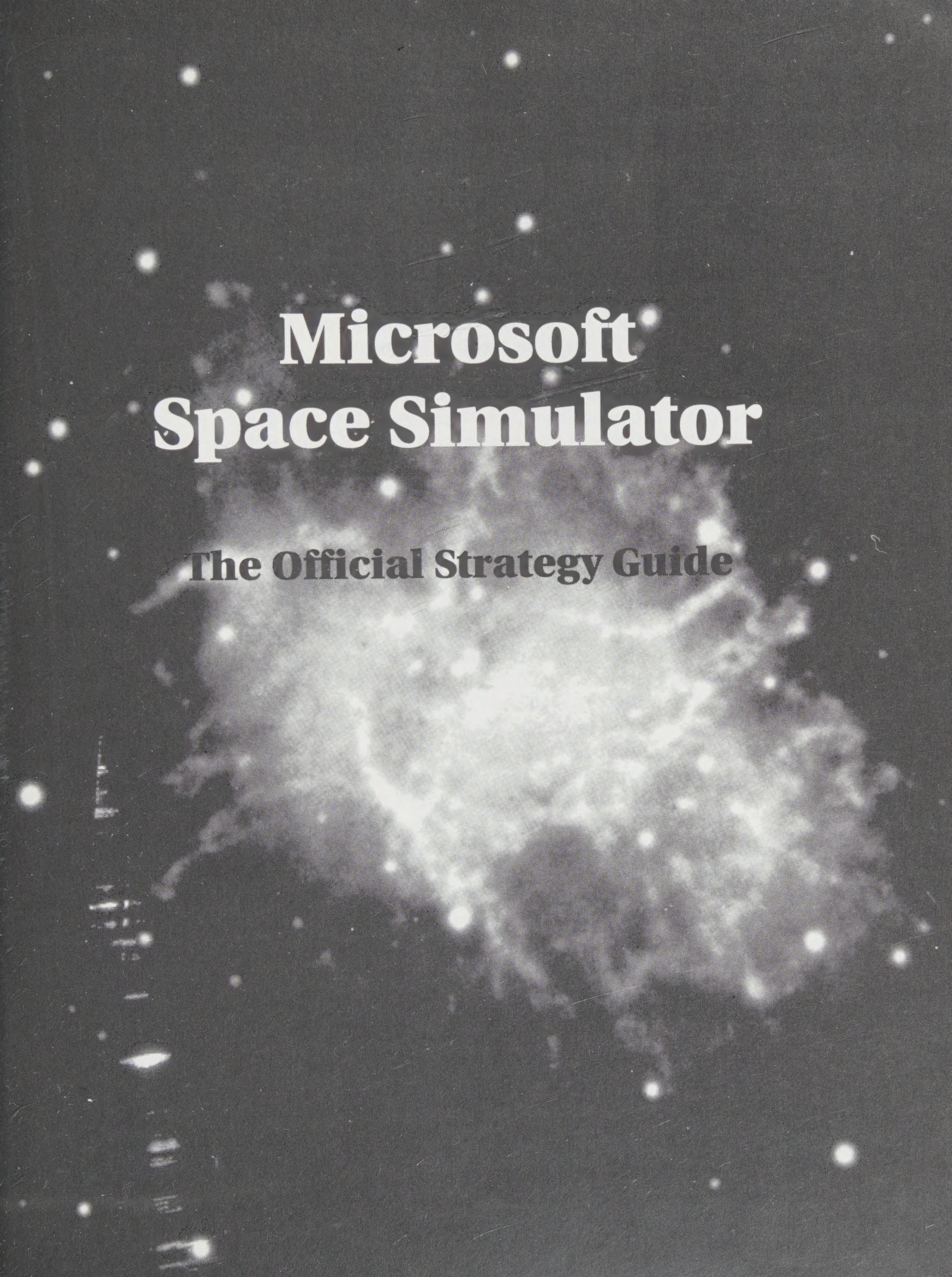

Microsoft Space Simulator

The Official Strategy Guide

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Microsoft
Space Simulator

The Official Strategy Guide

Rick Barba

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For Alex, Jake, and Luke

Acknowledgments

Space Simulator seems cosmically destined to be a classic. Indeed, the cosmic timing is almost too much: I am writing this on July 20, 1994, the 25th anniversary of humankind's first footsteps on the moon.

As if that weren't enough coincidence, this same week has treated humanity to an awesome celestial event, a once-in-a-millenium spectacle that has turned everyone's eyes skyward again. In the past few days we've watched a series of mountain-sized comet shards slam into mighty Jupiter at 130,000 MPH, raising titanic fireballs with the explosive power of millions of megatons of TNT.

These sorts of things make an author's acknowledgments even more fun to write. Obviously, my first thanks go to Microsoft Home and its *Space Simulator* development team for creating such a remarkable piece of software. In particular, thanks to Josh Davidson, John Solon, and Leigh Kole for their accessibility in the midst of product crunch time.

Thanks also to NASA (National Aeronautics and Space Administration), not only for such inspiring accomplishments as the moonwalk 25 years ago, but also for providing authors and every other citizen free access to its stunning library of photographic images. Thanks to my good friend Robin Chew for putting me on the right track in my search for NASA materials; to Grace Payne and Barbara Pope at NSSDC (National Space Science Data Center) for steering me to the best sources of information and images; to Karin King of BARA-King Photographic in Maryland for providing such timely NASA images; and to all my fellow authors noted in the bibliography, for educating me and providing the occasional pithy quote.

Finally, I need to thank those who contributed directly to the process of creating this book. First, my sincere gratitude and admiration goes out to Dean Denno, my technical editor based in Washington D.C. His careful, intelligent review of these pages made them far more accurate. I also want to convey special thanks to Kim Larson, my project editor, who cracked the whip in such a pleasant manner that I actually enjoyed being reminded repeatedly that I was running out of time, the sky is falling, etc. I must also mention that Marian Hartsough is responsible for the book design; as always, I find it elegant and entirely pleasing to behold.

I couldn't conclude this project without giving my usual thanks to Roger Stewart, my executive editor at Prima, for initiating the project and for his constant and much-appreciated support; and to Rusel DeMaria, originator of the Secrets of the Games series, for bringing me into Prima's writing stable.

—Rick Barba
July 20, 1994

Introduction

Welcome to this official companion guide for a remarkable new spaceflight simulation product from Microsoft Home. Before I get into the nuts and bolts of how to use this book, I want to ask you a simple question—one that, to my mind, underscores the true beauty of *Space Simulator.*

How big is the universe?

The answer: Nobody really knows. But here's a quick outward scan from home base to give you some perspective, courtesy of *The Starflight Handbook: A Pioneer's Guide to Interstellar Travel,* by Eugene F. Mallove and Gregory L. Matloff.

Picture the Sun as a marble, 1 centimeter in diameter. This scale leaves the Earth a mere dot, barely visible, sitting about 1 meter away from the Sun-marble. Now stroll out 42 meters to a smaller dot, Pluto, marking the outer bounds

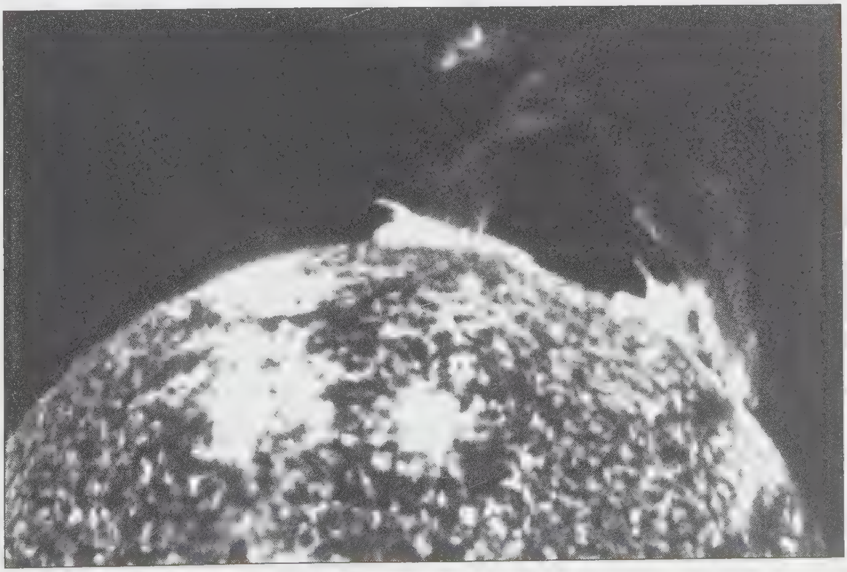


Figure 1
A Skylab *photo (1973) captures one of the most spectacular solar flares ever recorded. This twisted sheet of gas spans across 365,000 miles of the solar surface . . . yet on a cosmic scale, it's barely a spark.*

Figure 2 *On July 4, 1054, Chinese astronomers found a brilliant new light in the sky —a supernova "firecracker" brighter than a billion suns. Nearly a millenium later, the remnants of that celestial explosion form the magnificent Crab Nebula.*

of the Solar System. Remember: Earth is a dot, smaller than the period at the end of this sentence. At Pluto, you are about one-third the length of a football field from your home dot.

Next step: Find the nearest interstate highway on-ramp.

Stick out your thumb. Hitchhike 292 kilometers.

You have now reached Proxima Centauri, the nearest known star beyond the Sun. How long would it really take to reach this star, which is actually 4.3 light-years away? A very, very long time. Centuries, probably. According to *The Starflight Handbook,* today's interstellar vehicles would limp to Proxima Centauri slower than crippled ants could crawl the 292 kilometers in our Sun-as-marble analogy.

But let's not stop here. In astronomy, the mean distance from Earth to Sun is defined as one *astronomical unit,* or *AU.* Thus, one AU equals about 150 million kilometers. Proxima is 273,000 AU from the sun. That's about 41 trillion kilometers to the nearest star. Far enough for you? We're just getting started.

You probably know that light travels at a speed of 300,000 kilometers per second, and that a light-year equals the distance light travels in a year. Our pancake-shaped spiral galaxy, the Milky Way, is approximately 70,000 light-years in diameter, and it contains anywhere from 500 billion to a trillion stars.

Now check out the galactic neighborhood.

The nearest major galaxy is Andromeda, another glittering whirlpool spinning through space about 2 million light-years away. Andromeda joins the Milky Way and 18 other galaxies in our "Local Group" (sounds cozy, doesn't it?), including the spectacular Magellanic Clouds, which are irregular aggregations of billions of stars. The Local Group, in turn, is part of the Virgo supercluster—thousands of galaxies gravitationally linked in a delicate, twirling dance through

Figure 3 *The Great Andromeda Galaxy is the closest galactic neighbor to our own Milky Way . . . yet it's more than two million light years away.*

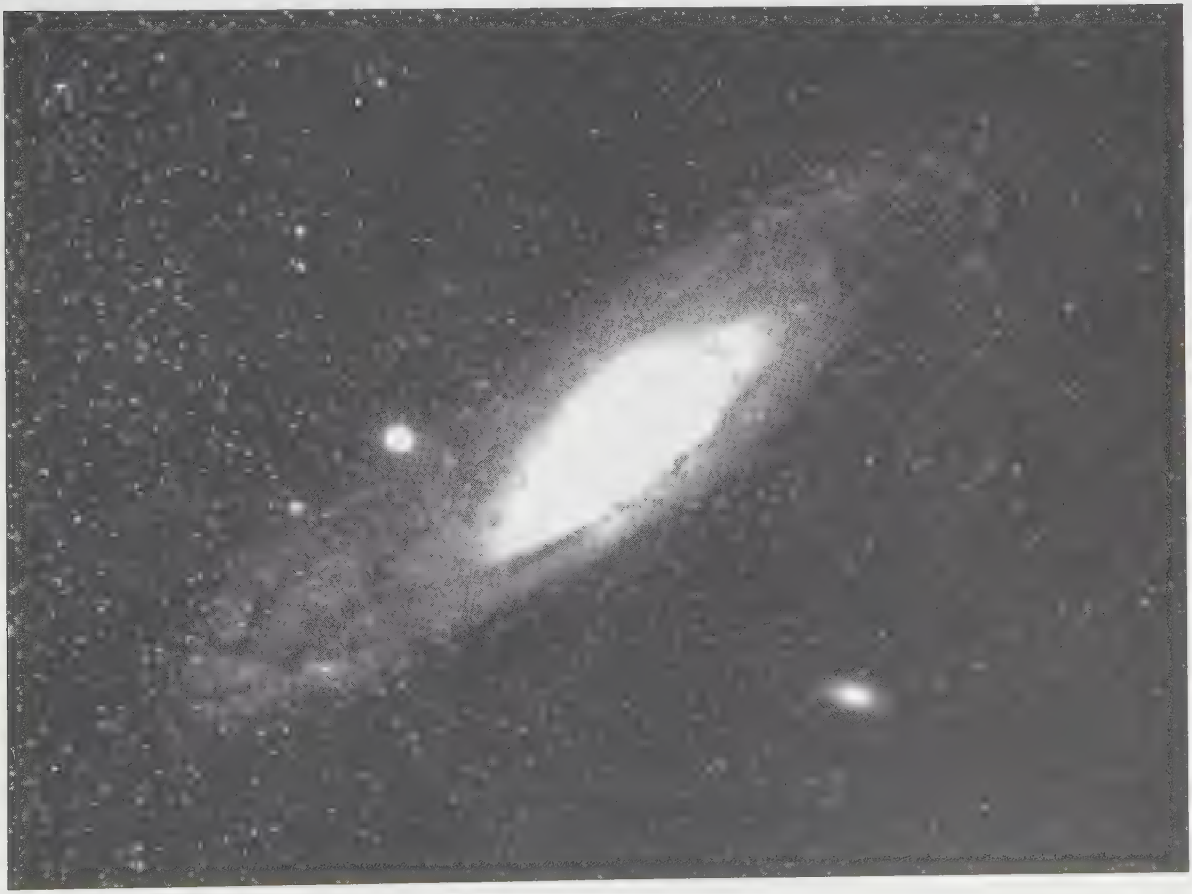


Figure 4 *The Rosette Nebula in Monoceros glows softly behind a few of the estimated 3 sextillion (three followed by 21 zeroes) stars in the known universe.*

the cosmos. Innumerable superclusters and even larger galaxy groups extend to the current "horizon" of visibility, which today stretches about 15 or 20 billion light-years deep into the void.

So, again, how big is the universe?

Big. Very, very big. Hundreds of billions of galaxies populate the visible sky, each containing hundreds of billions of stars. For the record, scientists estimate that the visible universe contains something like 3,000,000,000,000,000,000,000 (3 sextillion) stars. That's a lot of stars. And some theorists even argue that the visible universe isn't any more than a tiny "atom" of the whole cosmos. The cosmos may in fact be larger than the human mind can possibly envision—infinite, perhaps. Then again, it may not. Perhaps, as Albert Einstein hypothesized, the very fabric of space and time is itself enclosed within a fourth dimension, through which there is no escape.

In any case, astronomical numbers and cosmic ruminations help give us perspective on our planet, ourselves, and our place in the universe. As former shuttle astronaut Joseph P. Allen puts it in his eloquent book, *Entering Space: An Astronaut's Odyssey:*

> Our quarter-century of travel into space has awakened us to the fact that we inhabit a fragile and finite planet on which we depend totally. Before people around the world had seen pictures of our planet taken from earth orbit . . . it was difficult to grasp the truth that our home is just a sphere in space, a planet that orbits a rather ordinary star located in an inconspicuous corner of a minor galaxy.

Space Simulator celebrates this cosmic human awakening, and brings some of the beauty and exhilaration of spaceflight to people like you and me.

Figure 5
A spectacular view of "Spaceship Earth" as photographed by the crew of Apollo 17.

HOW TO USE THIS BOOK

This book certainly includes everything you need to know about *Space Simulator* to get it up and running. However, it's important to note that this is a strategy guide, not a manual. It is designed to complement the *Space Simulator Star-Pilot's Guide*, not simply reproduce it in another form.

So if you're looking for a step-by-step instructional guide for *Space Simulator*, let me suggest something radical: Read the excellent manual that Microsoft Home provides with each copy of the game. Fiddle around with the program a little bit. Then come back to this book.

On the other hand, if you're already familiar with *Space Simulator* basics, or if you want to deepen your general knowledge of space travel, or if you're just darned impatient, well, read on. Because my ultimate purpose is to bring

Figure 6 *A shimmering comet grows brighter as it nears the Sun. Intense solar heat transforms a dirty chunk of ice into a vaporous display of cosmic beauty.*

Space Simulator's shimmering cyberspace a little closer to the infinite glory of real space. A simulator is more enjoyable if you're familiar with what is being simulated.

To this end, my book is divided into two parts:

Part One provides a three-chapter background on space and spaceflight. It opens with a brief history of spaceflight—brief, of course, because man first penetrated the boundary of space only thirty-seven years ago. Then you'll take a short jaunt in the shuttle *Discovery* while reviewing some fundamental mechanics of spaceflight—how a rocket works, basic orbital physics, human physiology in space, and other issues. Finally, Chapter 3 takes you on a mesmerizing tour of the future of spaceflight, both short and long term.

Part Two puts you right in the captain's chair of your *Space Simulator*. Like you, I enjoyed the excellent tutorial-style format of Microsoft's *Star-Pilot's Guide*. It's nice to learn in a friendly, hands-on way. So I expanded on the notion. Rather than take you on a plodding, documentation-style walkthrough

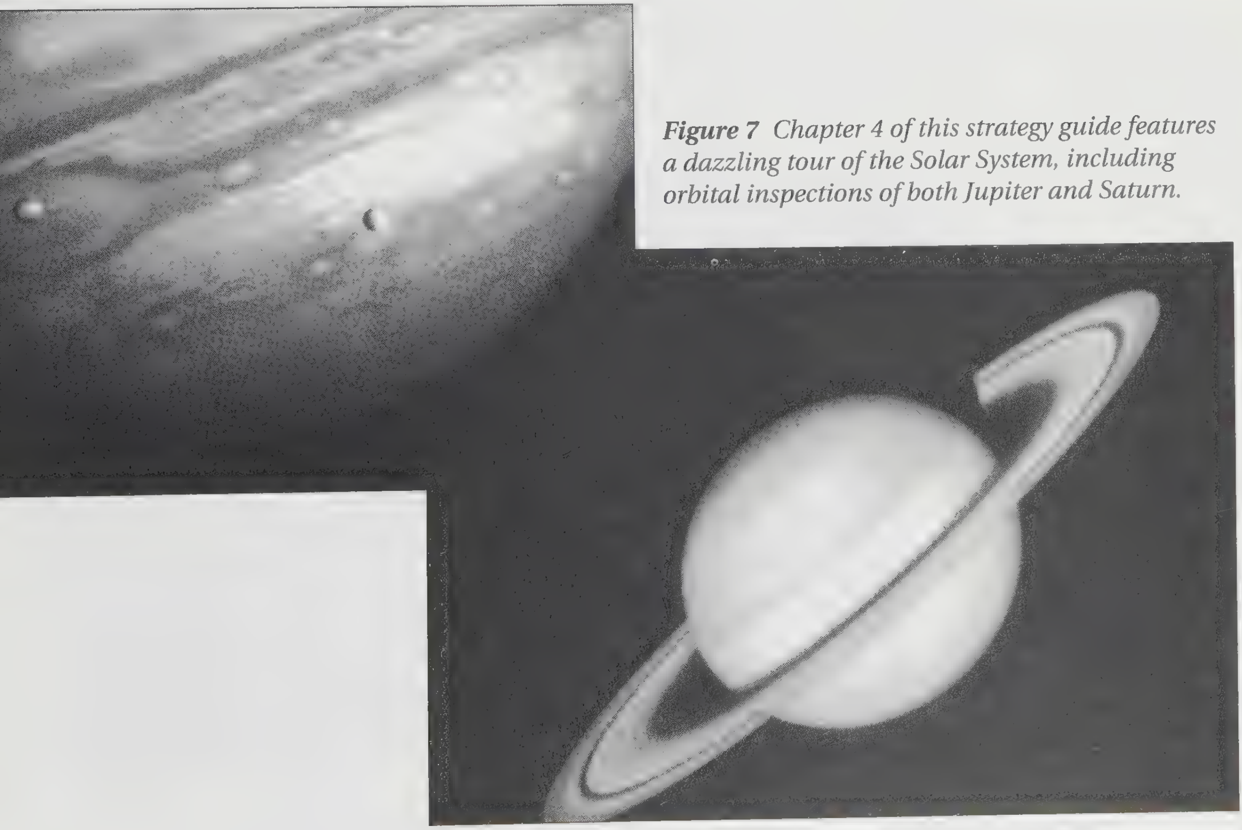


Figure 7 *Chapter 4 of this strategy guide features a dazzling tour of the Solar System, including orbital inspections of both Jupiter and Saturn.*

of the program, I've created three extended missions, complete with story lines, to help you explore the *Space Simulator* universe. Each mission lets you sample the splendors of the galaxy and beyond, while teaching you all the nifty functions and features of the simulator at the same time.

The first mission (Chapter 4) takes you on a dazzling voyage through the inner Solar System. Along the way, you'll learn how to get the most out of your *Space Simulator* viewing and recording tools. This chapter includes some professional film editing tips so that you can prepare taut, exciting videos of your intergalactic journeys.

The second mission (Chapter 5) charts a course for the stars. Its story takes you from Mars to a distant star system as you track the sudden, mysterious dislocation of the *Mars Orbiter*. You'll become familiar with the *Space Simulator* flight controls and do some nifty seat-of-the-pants piloting to get to the heart of the mystery.

Finally, the third mission (Chapter 6) will kick you out into deep space, where anything can happen. Only a keen understanding of your ship's flight computer and a firm grasp of orbital mechanics will keep you safe from the dark, ravenous black hole at the core of the Milky Way galaxy. (Don't worry, I'll try to get you through in one piece.)

Figure 8
Deep space features vast interstellar voids lit by patches of mysterious translucence. Example: The eery Horsehead Nebula in Orion. Orion is a stellar nursery—young protostars "nurse" on the nebula's vast cloud of hydrogen, gradually gathering enough matter to become adult stars.

Part One

Chapter 1

A Brief History of Spaceflight

“Separation from the carrier rocket completed.”

—Cosmonaut Yuri Gagarin, speaking the
first words by a human being in space

Man has long owned a surprisingly precise knowledge of the principles of spaceflight. After all, the basic laws of celestial motion were formulated almost four hundred years ago by Johann Kepler (1571–1630). As astronaut Joe Allen writes of his study of physics in the 1950s in *Entering Space*: "While I was studying Kepler's equations of orbital motion, they were dramatically demonstrated by the first orbits of *Sputnik*."

Johann Kepler

Sir Isaac Newton

Indeed, Sir Isaac Newton (1642–1727) built the theoretical framework for space travel clear back in the seventeenth century. You cannot be a star-pilot without a fundamental understanding of how inertial and gravitational forces work in the universe. Newtonian physics described these forces with remarkable accuracy. All of your flight control maneuvers in *Space Simulator*—with your Slew Control off, anyway—must take into account Newton's famous laws of motion and universal gravitation.

But of course, the road from such theoretical knowledge to technological know-how is usually long, arduous, and full of detours. Progress down that road often depends on things like serendipity, politics, economics, and military expediency. Even a visionary rocket scientist like Wernher von Braun had to be realistic about the gap between knowledge and know-how. In a 1963 article for *Popular Science* magazine, he wrote: "With our present knowledge, we can respond to the challenge of stellar space flight solely with intellectual concepts and purely hypothetical analysis. Hardware solutions are still entirely beyond our reach and far, far away."

At some point, however, technical know-how always reaches a point of critical mass. Then . . . well, the stars suddenly open up like flowers.

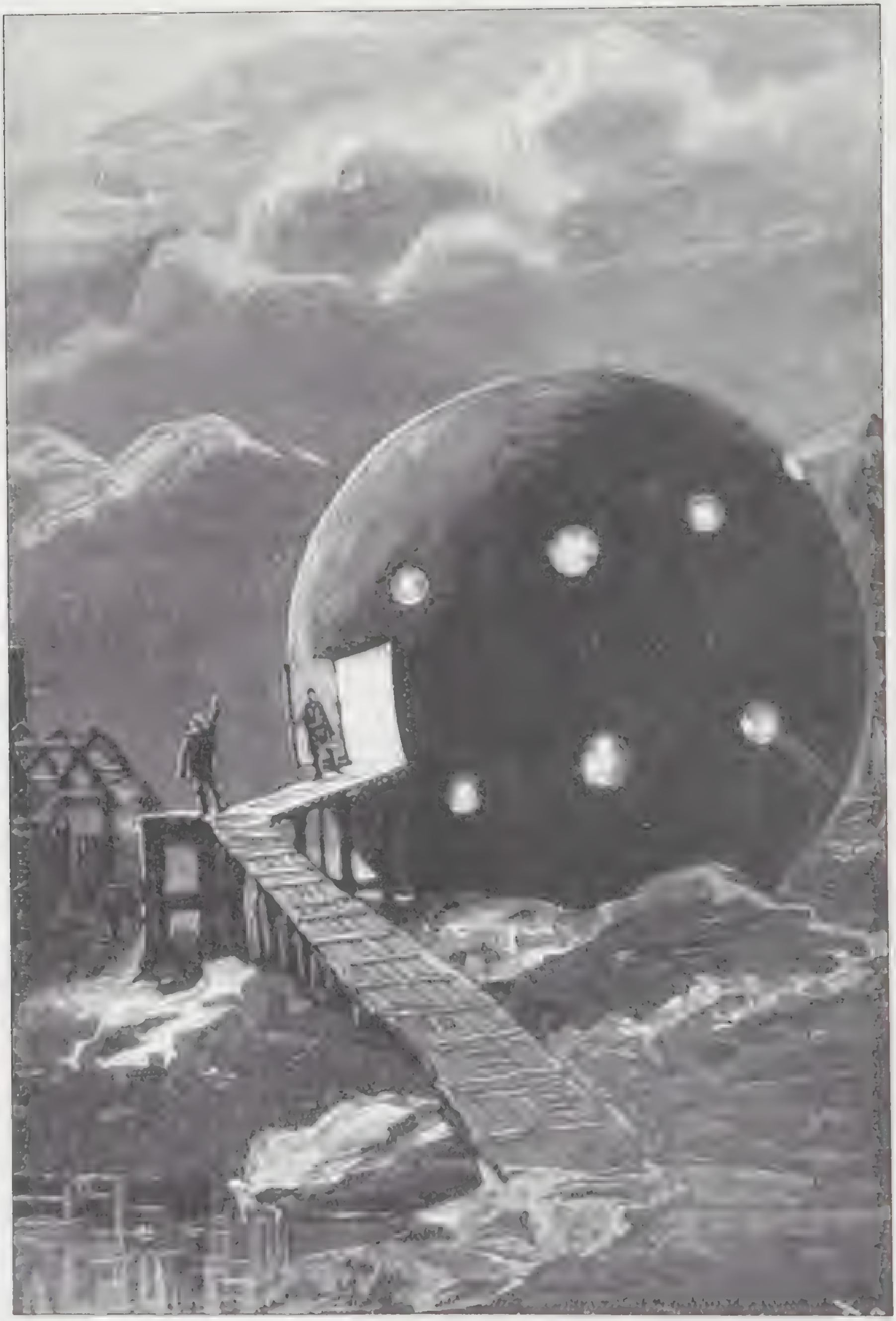


Figure 1-1
Visions of "anti-gravity drives" date far back in the history of man's imagination. Robert Cromie described one for this spherical starship bound for Mars in A Plunge into Space *(1891).*

Need an example? Consider this: Human beings have dreamt of exploring the sky (and designed a lot of failed flight technology) for centuries, if not millennia. But only sixty-six years elapsed between the day we first floundered aloft at Kitty Hawk and the day two men stepped from the *Eagle* to plant the first dusty footprints on the Moon.

"THE ROCKETS' RED GLARE"

If you've ever listened to the words of "The Star-Spangled Banner," perhaps you've wondered about the phrase, "the rockets' red glare." The song, in which Francis Scott Key recalls the British bombardment of Fort McHenry near Baltimore in 1812, speaks of a perilous fight that apparently involved rockets.

Rockets? In 1812?

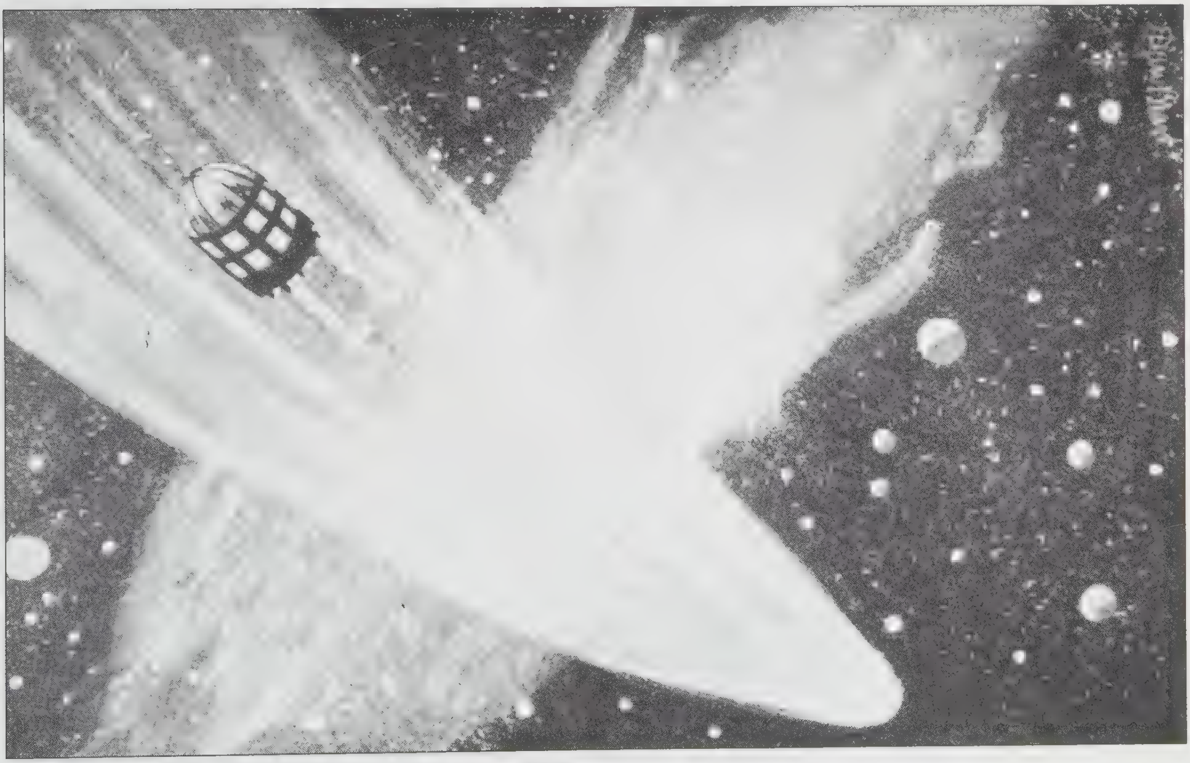


Figure 1-2 Space Simulator*'s gravity-driven starship* Callisto *has a literary ancestor. The first* Callisto *rides the tail of a comet in John Jacob Astor's 1894 science fantasy,* Journey to Other Worlds.

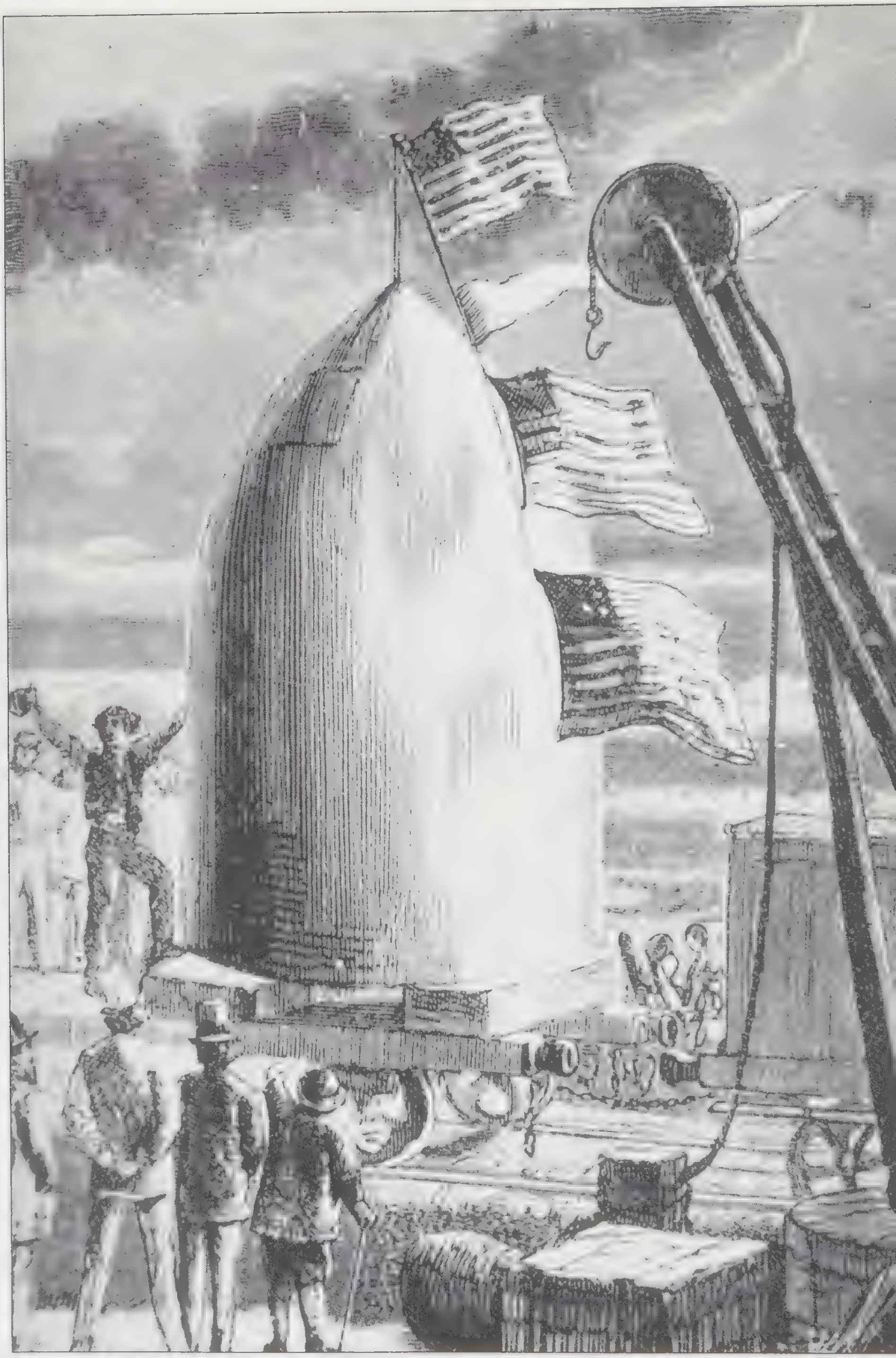
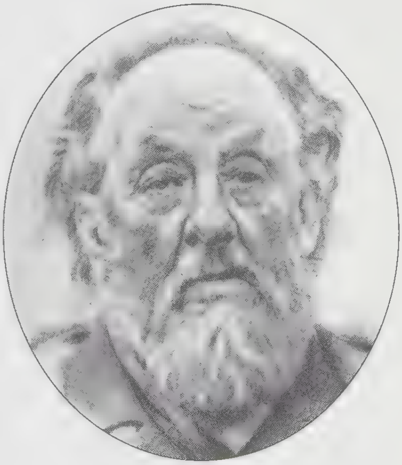


Figure 1-3
The works of Jules Verne inspired much early speculation on space travel. His classic tale, From the Earth to the Moon *(1865), relied on basic Newtonian physics and a massive cannon to propel man into space.*

The Chinese, of course, invented gunpowder a thousand years ago, and fairly sophisticated, gunpowder-fueled explosions have been propelling deadly projectiles through the air for centuries. But did you know that by 1812, a fellow named William Congreve at the British Royal Laboratory had actually designed a "rocket ship" christened the *Erebus*—a ship that could send solid-fuel missiles hurtling high through the atmosphere?

Maybe you didn't. But Jules Verne did. It was his knowledge of these nineteenth century rockets that inspired his famous musings on space travel. Relying on Sir Isaac Newton's third law of motion, which states that for every action there is an equal and opposite reaction, Verne theorized that a large enough "action" could propel a sealed capsule out of the atmosphere in *From the Earth to the Moon* (1865).

THE ROCKET PIONEERS



Russian scientist Konstantin Tsiolkovsky — the father of modern astronautics. He calculated escape velocities, developed other mathematics of spaceflight, and wrote extensively of space colonization.

Around the turn of the century, Konstantin Tsiolkovsky, a Russian schoolteacher, first worked out the mathematics showing how a rocket could overcome the pull of Earth's gravity and propel itself into space. Founder of the modern science of astronautics, Tsiolkovsky developed theories of space travel and wrote many books on his dream of space colonization. Some of these books were in the tradition of Jules Verne, and, like our best science fiction writers of today—Asimov, Heinlein, Clarke—Tsiolkovsky based his fiction in true science. His work inspired generations of Russians to grow up with notions of spaceflight prominent in their young imaginations.

In the early 1900s, an American scientist named Robert H. Goddard experimented with true rocketry, testing different types of fuels. It is important here to point out the difference between what scientists call a "true rocket" and one propelled by jet power. In each case, burning fuel pushes the projectile forward. But fuel needs an *oxidizer* to burn. Now, a jet is indeed a rocket, but it uses oxygen from the atmosphere as its oxidizer. In space, where there is no air, a jet engine could not burn its fuel.

A true rocket carries its own oxidizer. It mixes the fuel and oxidizer, then ignites the mixture in a combustion chamber. The escaping gases of this controlled explosion create propulsion. Thus, a burn is possible regardless of the presence of atmosphere. (For more information on rocket propulsion, see "How a Rocket Works" in Chapter 2.)

Goddard was excited to discover that certain mixtures of fuels and oxidizers could burn quite well in an airless compartment that simulated the vacuum of space. In 1926, he became the first person to successfully launch a liquid-fueled rocket. It was a small rocket, but a huge achievement.

Unfortunately, Goddard's work was largely ignored by both the military and scientific communities in the United States. At about the same time, a Rumanian student in Germany named Hermann Oberth published a slim book in which he described a hypothetical spaceship that used rocket power to blast into space. His theoretical work, unlike Goddard's, was highly praised and valued by his government's institutions.

Eventually, Oberth's ideas and personal influence led to the development of a long-range, liquid-fueled missile. Unfortunately, this development occurred under the auspices of the German War Department at a time when German destiny was seized by the warlike fist of Adolf Hitler.

American Robert H. Goddard conducted many of the first "true rocketry" experiments. In 1926, he became the first to launch a successful liquid-fuel rocket.

Transylvania-born Hermann Oberth became the first in a long line of celebrated rocket scientists in Germany. His work inspired young Germans such as Wernher von Braun, who would become the most prominent force in modern rocketry.

V-2: THE FIRST TRUE ROCKET

Oberth, it is interesting to note, served as technical advisor on a groundbreaking movie by the great German director Fritz Lang. The film, *Die Frau im Mond* (The Woman on the Moon), has been cited by Wernher von Braun as a powerful early influence in his career. Von Braun went on to become a prominent force in modern rocketry. His early work as director of the German rocket program resulted in a brilliant but deadly achievement. Dubbed the V-2, it was the first truly successful rocket, roaring off launch pads in German-held territory, traveling hundreds of miles at 3,500 MPH to its target in England and elsewhere.

Resembling a torpedo with its four fins, the V-2 was powered by a mixture of liquid oxygen and alcohol. At the highest point of its trajectory (or *flight path*), it could reach an altitude of more than 60 miles—a region of the stratosphere that could be considered the lower rungs of space. Thus, by some standards, the V-2 was the first man-made spacecraft. It is ironic, but not unusual, that a horrific instrument of war should be the first breakthrough in aerospace technology.

In the perilous final days of the war, Wernher von Braun led a cadre of fellow rocket experts in a remarkable escape from the Third Reich. After sealing tons of highly sensitive research documents in a secret cave in Bavaria, the group slipped through the Nazis' collapsing Western Front into the waiting arms of General George Patton. They brought with them dozens of cars packed with veteran personnel, records, and equipment—a mother lode of know-how that became the core of the U.S. missile program in the next two decades.

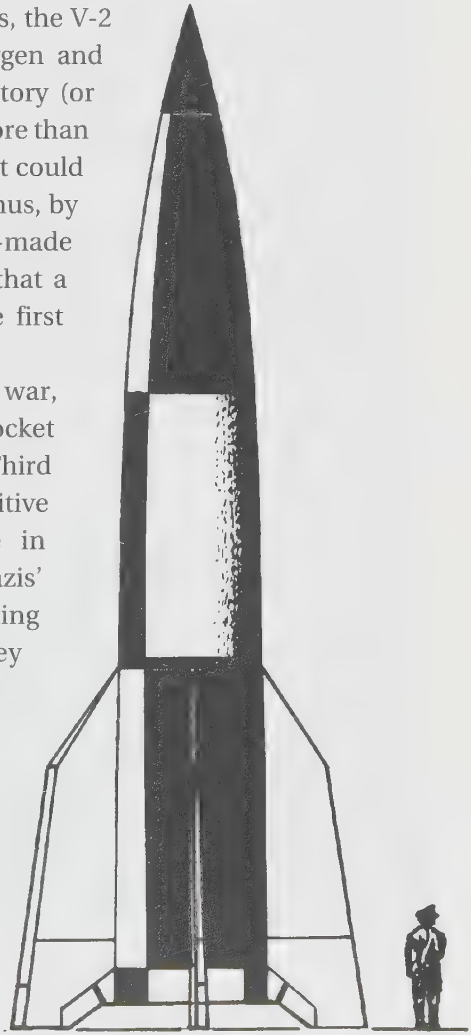


Figure 1-4 *The first true rocket was also a terrifying instrument of war. The German V-2 brought supersonic terror into the heart of the British homeland during World War II.*

THE 1950s: THE SPACE RACE HEATS UP

The Russians, by the way, garnered their own share of German rocket expertise after the war. Indeed, the white-hot race into space that dominated the 1950s became an ironic question: Who had the better Germans?

America's rocketry program set up shop at the White Sands Proving Grounds in New Mexico. In the years after the war, former German scientists and a few American colleagues restarted the V-2 program where it had left off at the German military's greatly feared Peenemünde Launch Site on the Baltic Sea during the war. (Later, when Wernher von Braun set up his headquarters in Huntsville, Alabama, it jokingly became known as "Peenemünde South.")

It was at White Sands that American efforts began to focus on the first major barrier to space travel. In order to reach the boundary of outer space, scientists needed to overcome the fundamental problem of thrust-to-weight ratio. One pound of chemical fuel would not provide enough thrust to lift its own weight into orbit from the surface of the Earth. The fuel burned itself out long before it could escape the pull of gravity.

Figure 1-5 *The rocketry experts of the Von Braun team—seen here at their famous White Sands Proving Grounds in New Mexico—formed the heart of America's space program in the 1950s and early 1960s.*

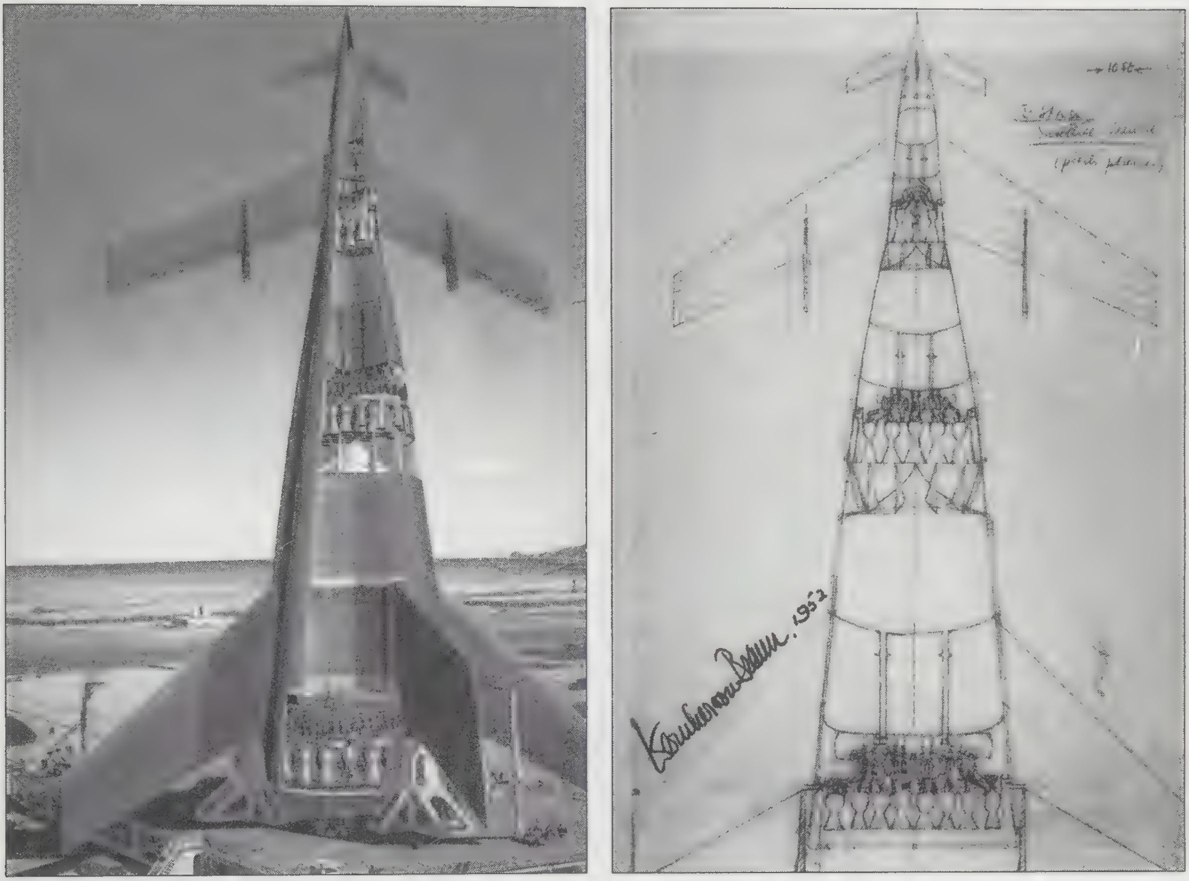


Figure 1-6 *Rocket scientists overcame thrust-to-weight ratio problems by creating multistage rockets. In 1951, Wernher von Braun designed a massive three-stage rocket that would require a staggering* ninety *rocket engines to achieve orbit! Next to von Braun's blueprint is artist Rolf Klep's cutaway rendition of the 7,000-ton launch vehicle.*

The answer: Create a multistage rocket. A large, powerful first stage lifts and accelerates the entire rocket, creating tremendous momentum. When it burns out, its heavy, empty fuel cannister drops away, and a second stage ignites. This stage, in essence, is a new liftoff—one accomplished at great altitude with the benefit of the tremendous upward velocity already provided by the first stage burn.

Early American efforts focused on two-stage hybrids which featured small WAC Corporal rockets attached to the top of modified V-2 rockets. These efforts brought some exciting early success. But, as you shall see, most of the space firsts of the 1950s and early 1960s were achieved by the Soviets.

October 4, 1957: *Sputnik*

In the autumn of 1957, the Soviet space program stunned the world when *Sputnik 1*, the world's first artificial satellite, thundered into space. It circled the globe for twenty-one days, reaching an *apogee* (highest point of an elliptical orbit) of 588 miles.

A gleaming metallic globe, *Sputnik* was about the size of a basketball and weighed a mere 184 pounds. Yet this tiny package caused a panic in America. One month later, the Soviets sent the first living creature into orbit, a dog named Laika, in *Sputnik 2*. Soon after that, a frantic U.S. space program launched its first serious attempt to reach outer space, a *Vanguard* rocket. It lost thrust after two seconds, then blew up. It wasn't until January 31, 1958, that the *Explorer 1* made it into orbit, and the United States finally became a space-faring nation.

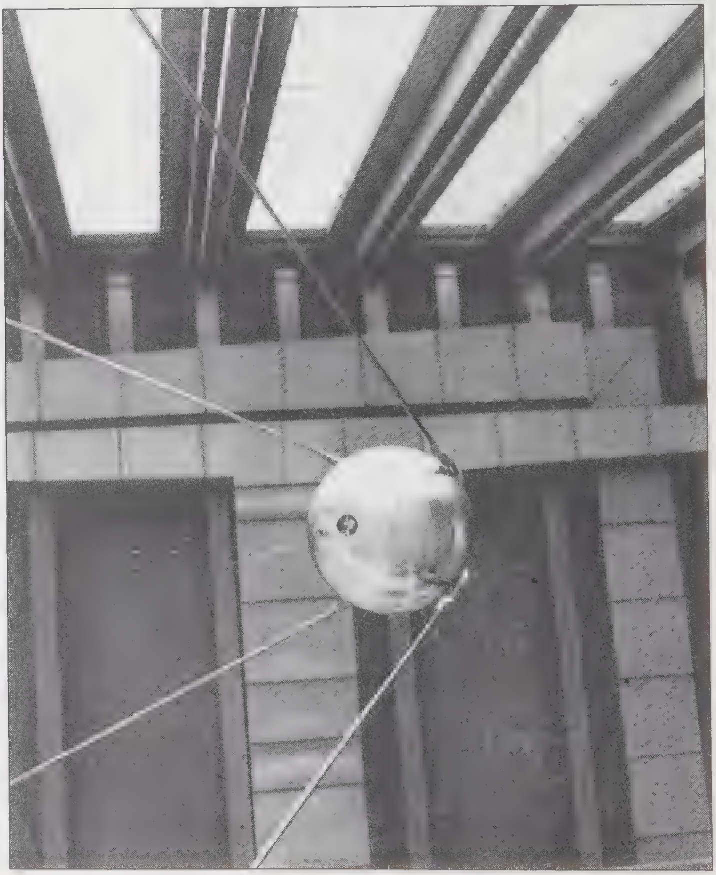


Figure 1-7
The launch of Sputnik *by the USSR was truly a "shot heard round the world." The first manmade object in space was a hollow metal globe only 23 inches in diameter— about the size of a basketball.*

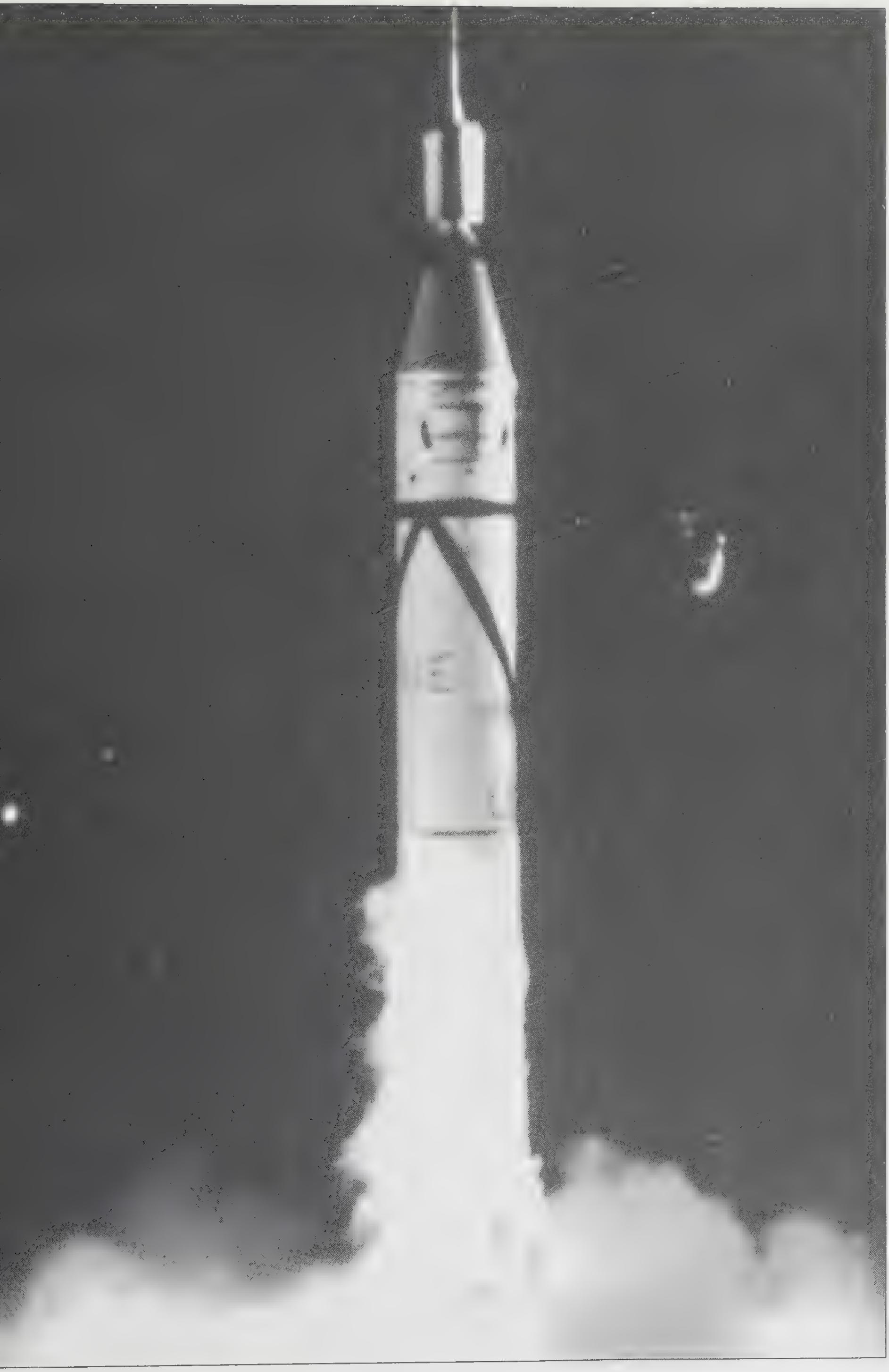


Figure 1-8
The United States finally crosses the boundary of space on January 31, 1958, with the successful launch of Explorer 1.

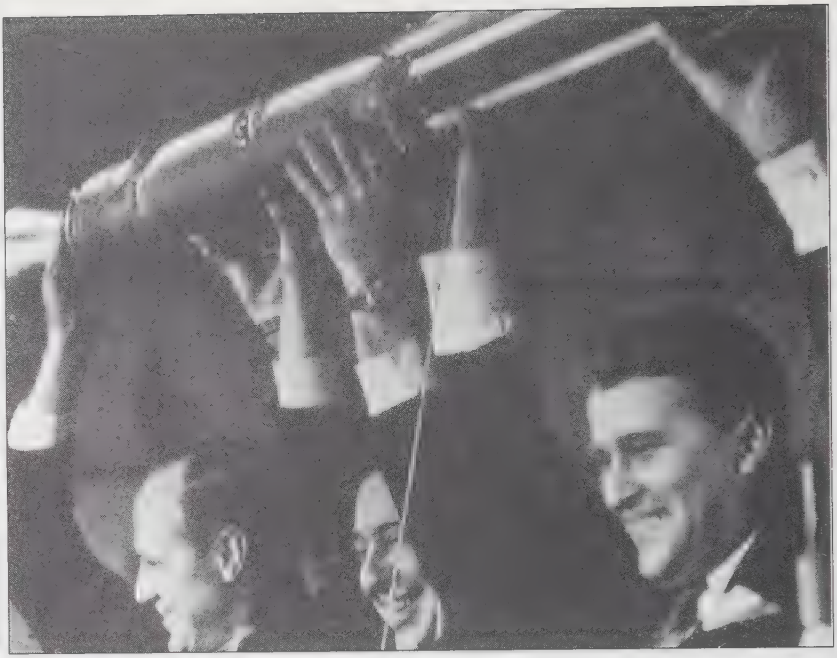


Figure 1-9
The three men responsible for the success of Explorer 1 *are (left to right) William H. Pickering, director of the Jet Propulsion Laboratory; scientist James Van Allen, whose instrument detected the radiation belts named after him; and Wernher von Braun, head of the U. S. Army rocketry group that built the critical first stage of the Redstone rocket that pushed the satellite into orbit.*

Explorer 1, by the way, managed to stay aloft for more than five months. The information it transmitted allowed scientists to discover the Van Allen Radiation Belts, the doughnut-shaped regions of high-energy charged particles trapped in the Earth's magnetic field.

PROJECT MERCURY AND THE SOVIET COSMONAUTS

Despite America's redoubled efforts, the next great first was achieved by the Soviets less than four years after *Sputnik*. On April 12, 1961, Yuri Gagarin rode *Vostok 1* up into a single orbit of the Earth to become the first human into space.

America made a face-saving answer less than a month later when, on May 5, Alan Shepard, the first American astronaut in space, took a relatively short jaunt up to an altitude of 300 miles. But although NASA managed to get this and a second manned Mercury mission into space in succeeding months, both were suborbital flights.

The Soviets sent another cosmonaut, Gherman Titov, into space in August, and he stayed in orbit for an entire day. It wasn't until more than six months later—February 20, 1962—that U.S. astronaut, John Glenn, riding an Atlas

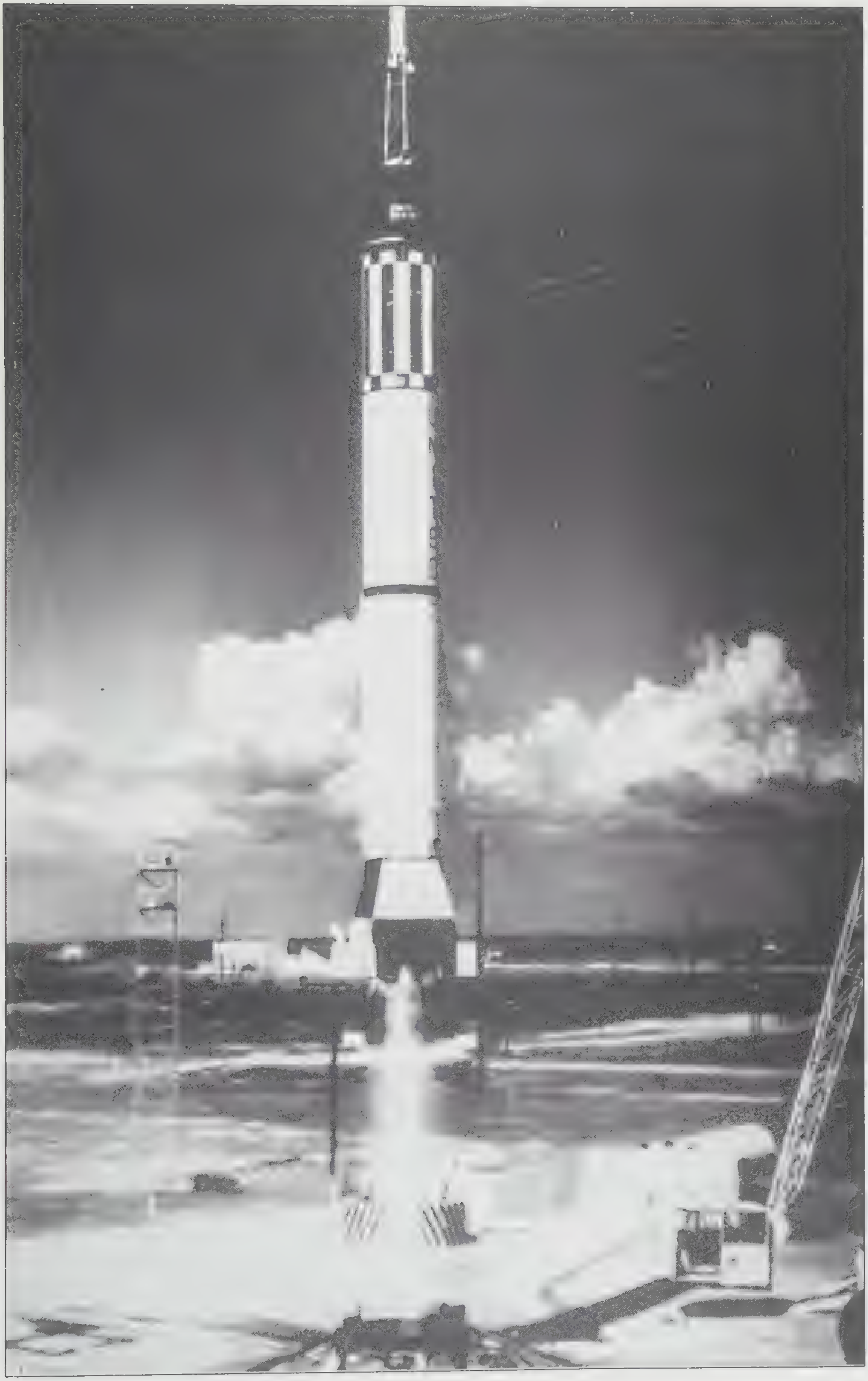


Figure 1-10
Alan Shepard becomes the first American in space on May 5, 1961. His spacecraft, named Freedom 7, *would only make a suborbital flight, however.*

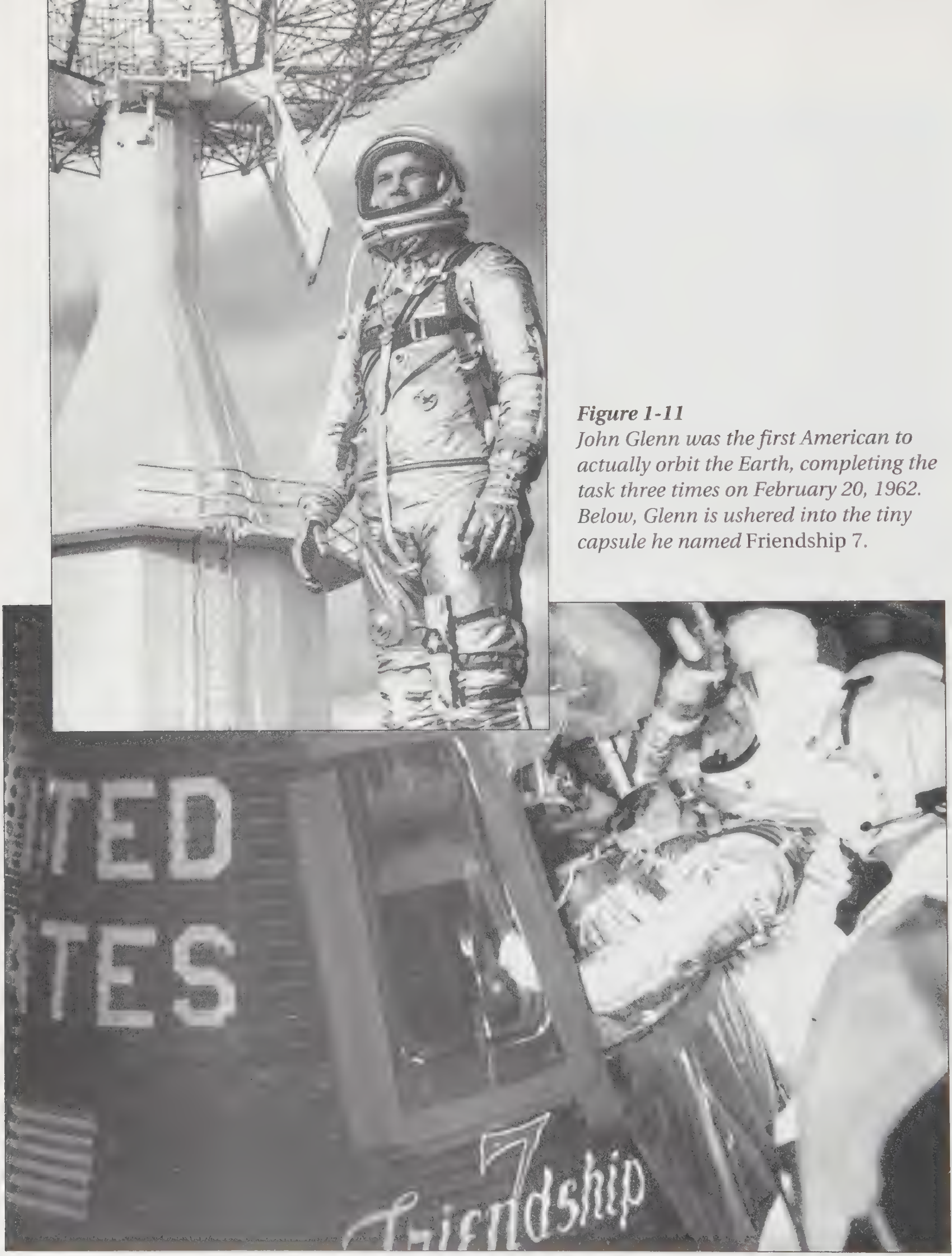


Figure 1-11
John Glenn was the first American to actually orbit the Earth, completing the task three times on February 20, 1962. Below, Glenn is ushered into the tiny capsule he named Friendship 7.

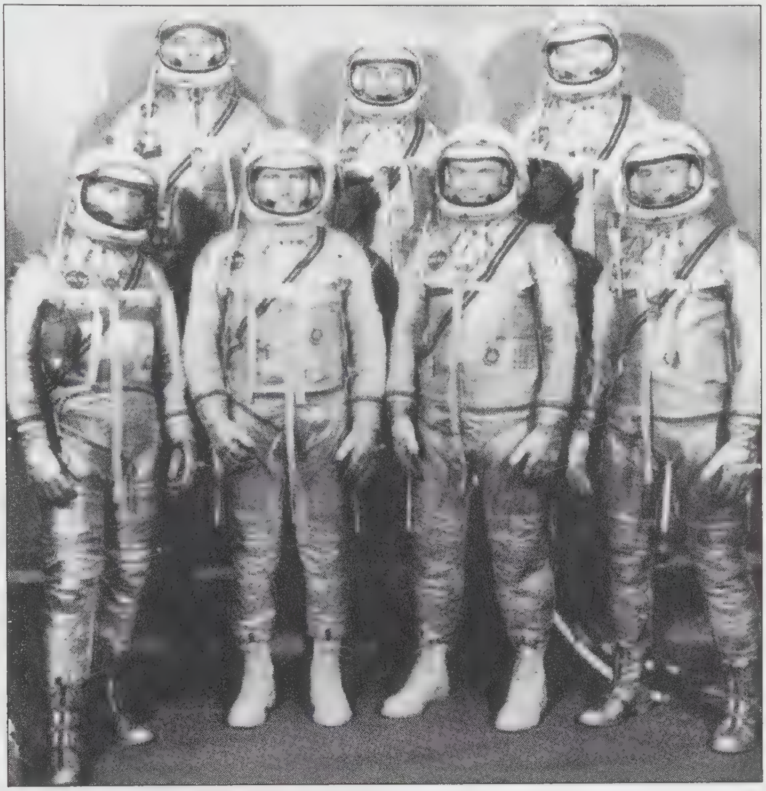


Figure 1-12
The seven astronauts of the Mercury project.

rocket topped by a capsule dubbed *Friendship 7*, managed to duplicate the feat of completing an orbit around the planet.

SPACEWALKING AND DOCKING: *GEMINI*

The Russians continued to set the early records in the space race. In 1963, they put the first woman into orbit, Valentina Tereshkova. (The United States would not send a woman aloft until June 18, 1983, when Sally Ride crewed aboard the shuttle *Challenger.*) Then, in 1965, a Soviet cosmonaut (Alexei Leonov) executed the first spacewalk.

Meanwhile, the U.S. space program jumped to its next phase, the two-man spacecraft of the Gemini program. At first it was a dazzling success. *Gemini 3* launched on June 3, 1965, and astronaut Ed White exited the capsule to conduct the first space walk by an American. In December of the same year, *Gemini 6* and *Gemini 7* maneuvered to within a single foot of each other.

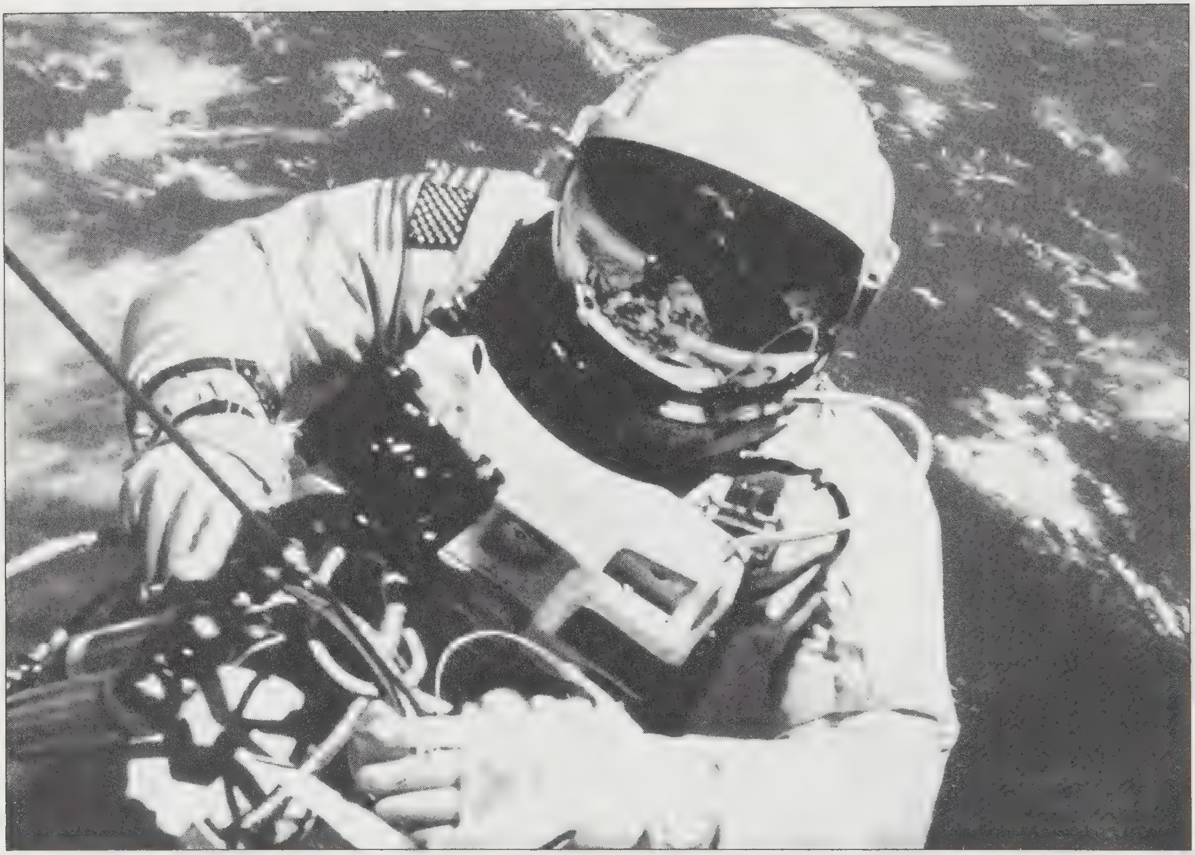


Figure 1-13 *Astronaut Edward White takes the first U. S. spacewalk when he ventures out from his* Gemini 3 *capsule on June 3, 1965.*

But near-tragedy struck in March of 1966. Shortly after the world's first successful docking maneuver (with an unmanned Agena Target Vehicle), astronauts Neil Armstrong and David Scott found their *Gemini 8* vehicle gyrating wildly out of control. The cause: a jammed-open thruster jet: After several anxious minutes, the problem was solved, and the astronauts managed a safe emergency splashdown.

While the Gemini program was a big step forward for NASA, it was still far from an ideal spacecraft from a human standpoint. Astronaut Michael Collins, who guided *Gemini 10* to a successful rendezvous with two separate targets, spent seventy-one hours inside a spacecraft that he compared to "the front seat of a Volkswagen Beetle."

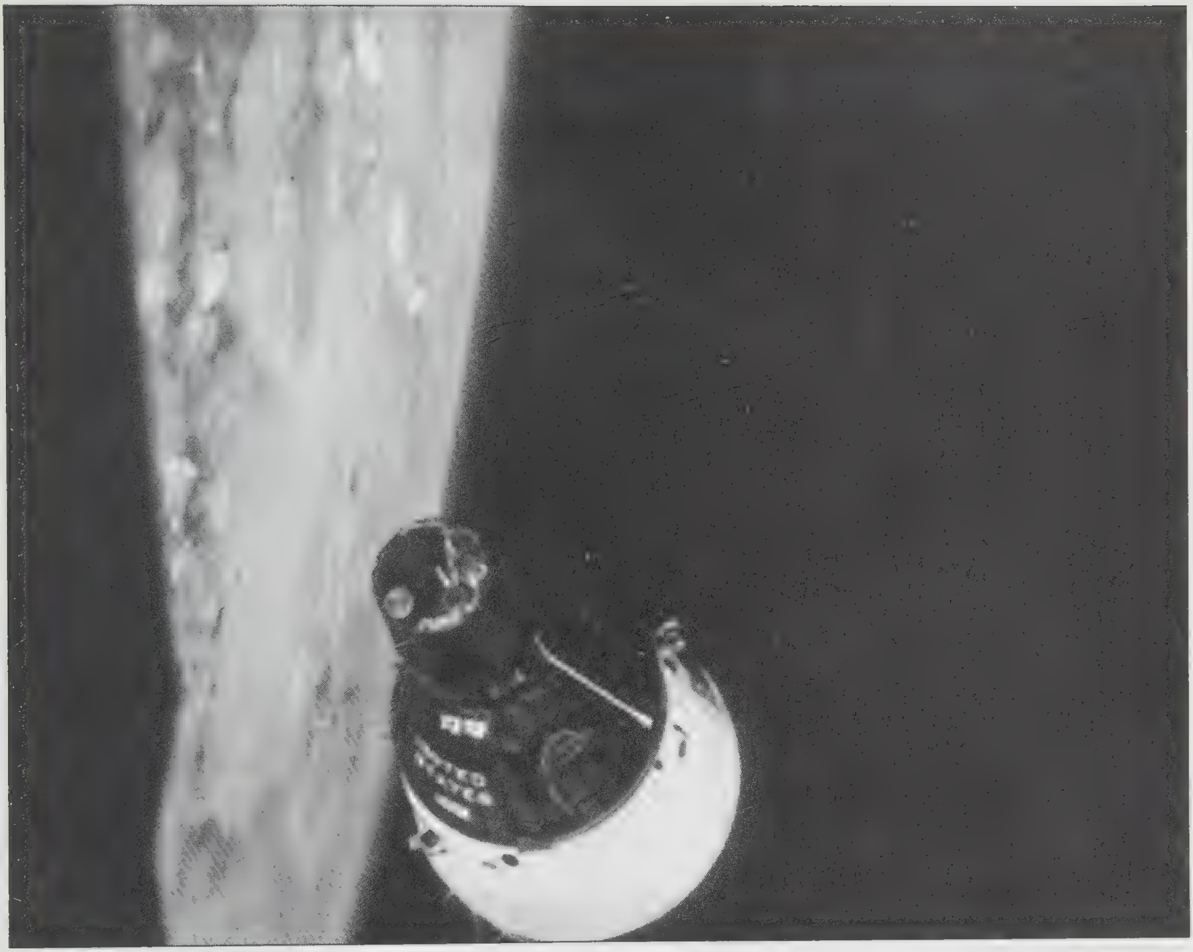


Figure 1-14 Gemini 6 *approaches a rendezvous with* Gemini 7 *in orbit. The two spacecraft got within a single foot of each other—a huge stride forward in space navigation and maneuvers.*

ONE GIANT LEAP: PROJECT APOLLO

Barely a month after Yuri Gagarin became the first man in space in 1961, President John F. Kennedy made a dramatic address to a joint session of Congress. He said: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to Earth." Thus began a technological endeavor of epic proportions, with a near-mythic target destination.

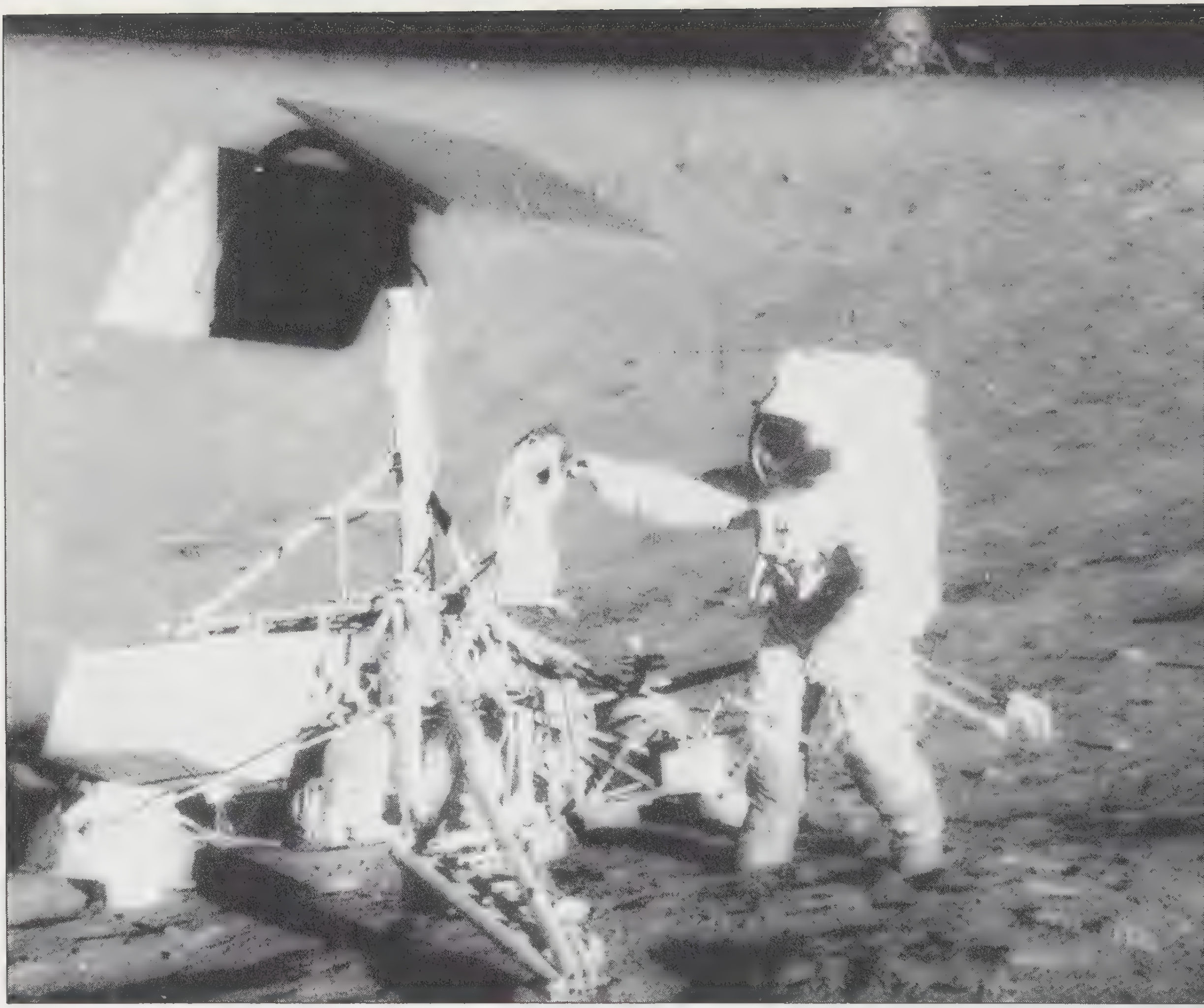


Figure 1-15 *The* Surveyor *series of lunar landers proved to be a resounding success for NASA. Here, a moonwalking astronaut visits the landing site of* Surveyor 3. *(Note the* Apollo 12 *lunar lander in the distance.)*

The Moon race actually began with the Soviet *Luna* and U.S. *Ranger* programs, each of which sent unmanned probes to lunar targets. Early probes carried out flyby, then impact, then orbital missions to the Moon. Finally, in 1966, the unpiloted Soviet probe *Luna 9* made the first successful soft landing on the Moon. Shortly thereafter, the U.S. *Surveyor 1* became the first in a remarkable series of lunar soft-landing successes.

The docking successes of the Gemini craft set the stage for the next phase of the U.S. program, known as *Apollo*. Scientists had determined that docking

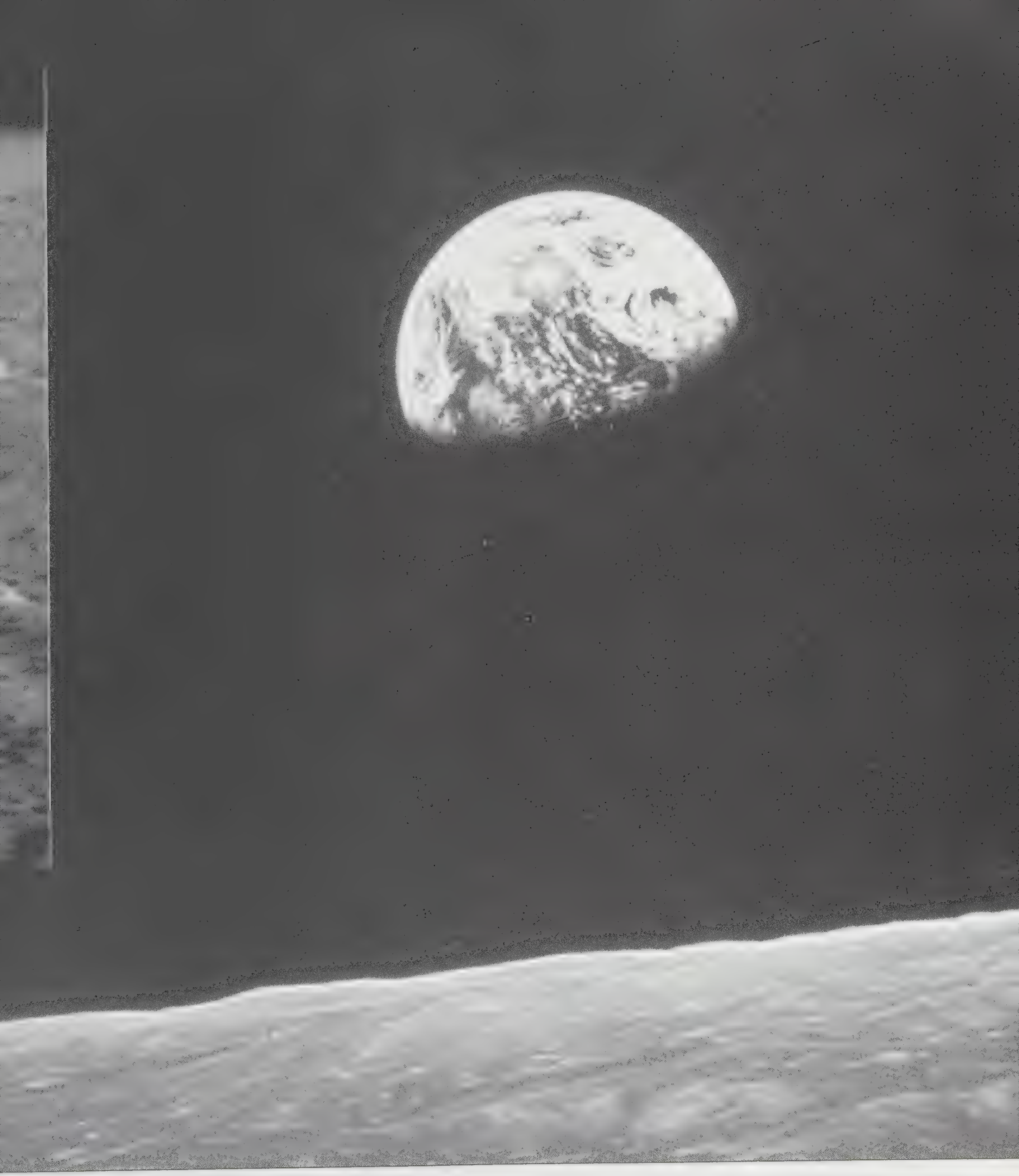
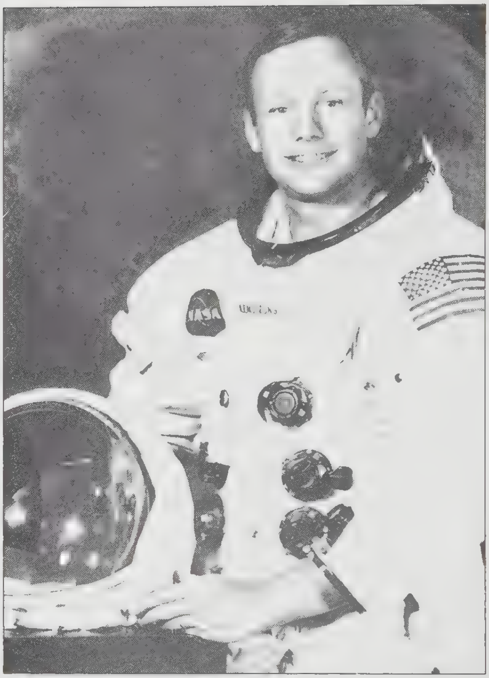


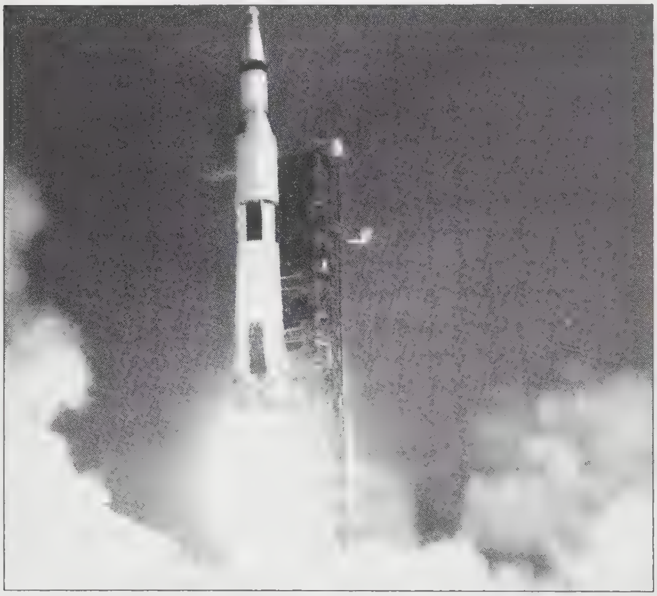
Figure 1-16 *Earth glitters blue over the lunar horizon. This spectacular view was photographed by the crew of* Apollo 8, *the first human beings to orbit the Moon.*

Apollo Moon Landings

Here are some of the stars and highlights of the Apollo program, featuring mankind's first expedition to another planet. In all, six different Apollo missions landed on the surface of the Moon, leaving the footprints of twelve different astronauts behind. The monumental effort cost $54 billion and engaged the efforts of more than 350,000 workers.

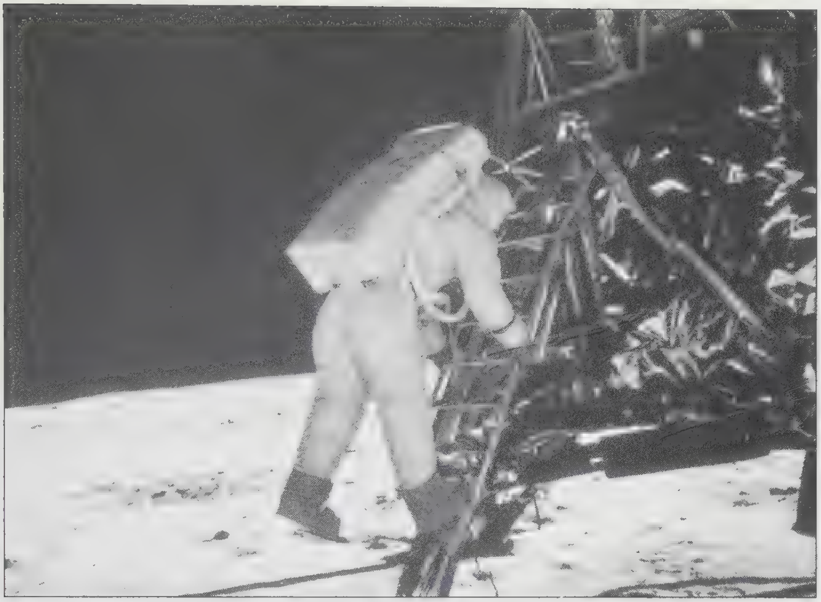


On July 20, 1969, Neil A. Armstrong became the first human being to set foot on another world. His legendary first words as he stepped onto the lunar surface: "That's one small step for man, one giant leap for mankind."

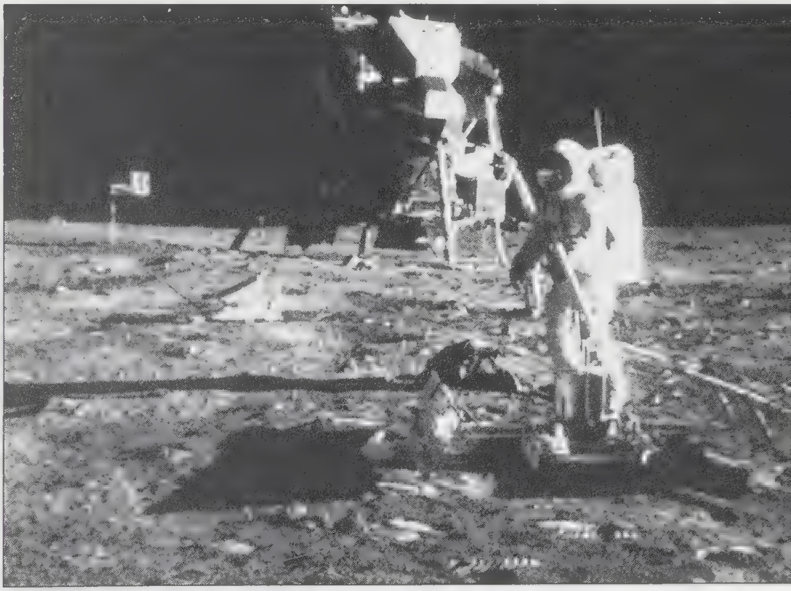


A gigantic Saturn 5 *rocket lifts off its Florida launch pad on July 16, 1969. Somehow, this 363-foot-tall, 3800-ton monstrosity rose from Earth on a thundering pedestal of flame, hurtling the three astronauts aboard* Apollo 11 *to a date with destiny.*

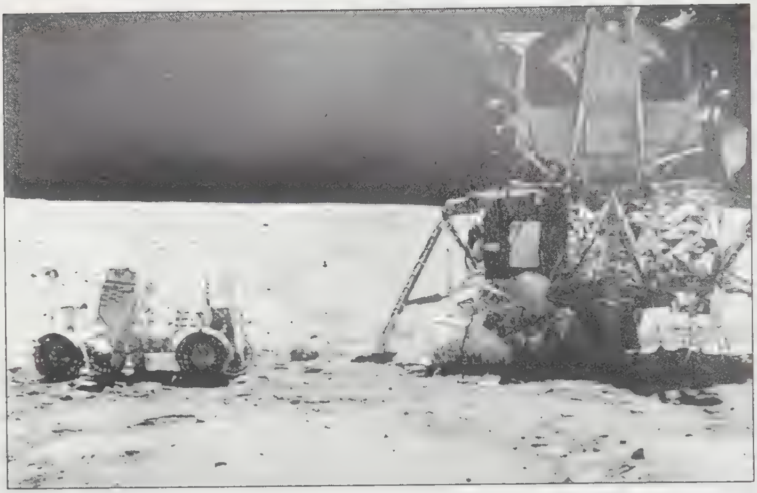
A dusty footprint in the lunar soil marks a stunning achievement in science and technology. The Apollo 11 *moonwalk left this print just eight years after humanity's first foray into space . . . and a mere 66 years after the Wright brothers first struggled aloft at Kitty Hawk, North Carolina.*



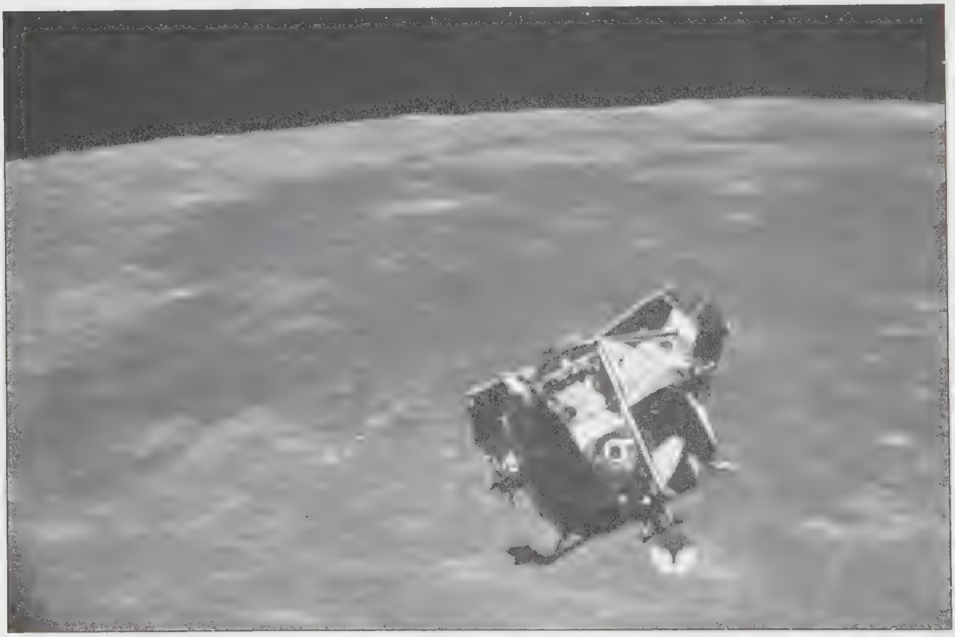
Edwin "Buzz" Aldrin, Jr., descends the ladder of the Eagle, *the lunar lander of the* Apollo 11 *mission. He is about to become the second human being to set foot on the Moon.*



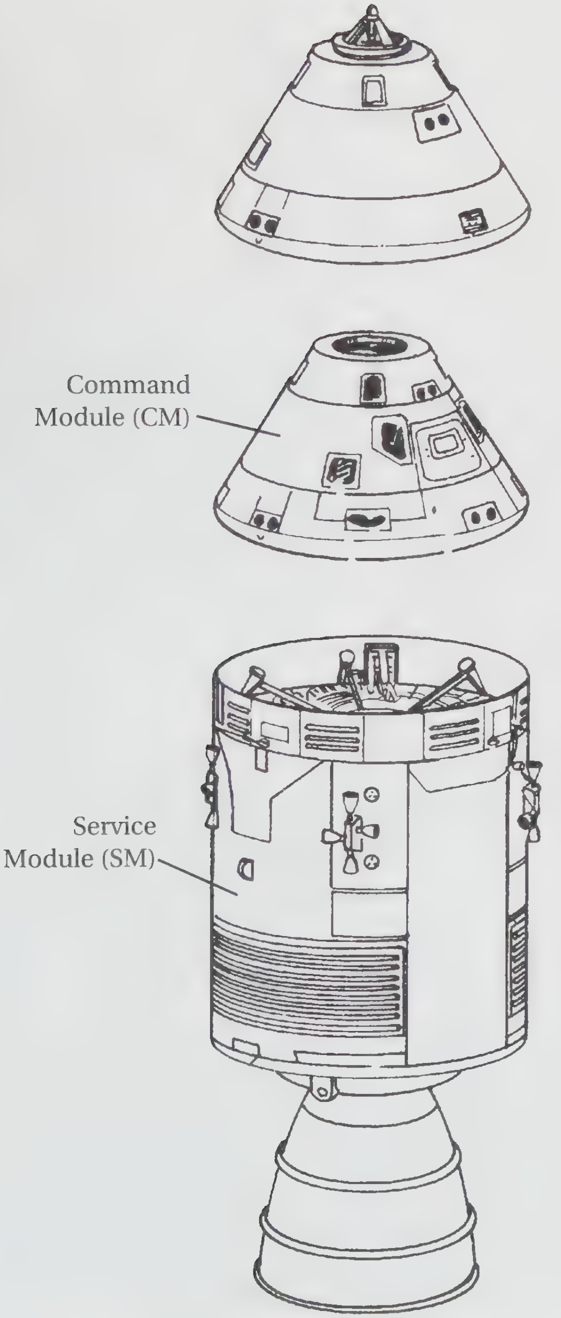
"Houston, Tranquility Base here. The Eagle *has landed." These historic words announced the establishment of the first human outpost on another planet.* Left: *This famous photo of Buzz Aldrin was taken by Neil Armstrong, who can be seen reflected in Aldrin's helmet visor.* Above: *Aldrin deploys a lunar experiment at Tranquility Base.*



Astronauts of later Apollo missions explored miles of the lunar surface with the aid of an electric "moon buggy" known as the Lunar Rover. In the shot above, astronaut John Young works on the Rover next to the LEM (Lunar Excursion Module) during the Apollo 16 *Moon landing in 1972.*



Astronaut Michael Collins captures the ascent stage of the lunar lander Eagle *as it returns to the* Apollo 11 *command module. Men last walked on the Moon in 1972. Will there ever be a permanent Moon base?*



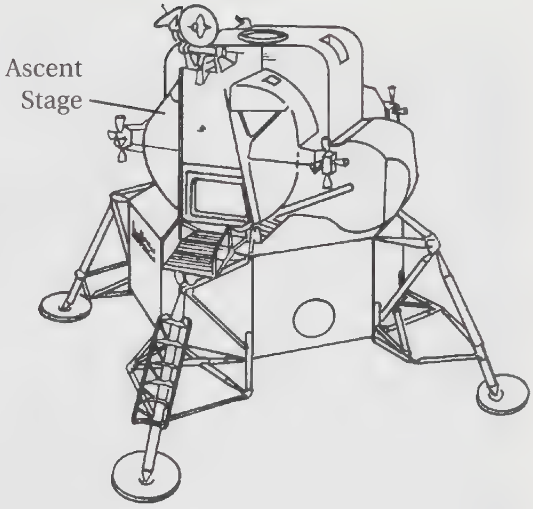


Figure 1-17 *The Apollo spacecraft: The Lunar Module (above) detaches from the tip of the Command/Service Module (CSM) to land on the moon. Only the Ascent Stage returns to the CSM, leaving the Descent Stage (the base and the landing footpads) behind on the Moon's surface.*

Once the moonwalkers safely reboard the CSM, the Ascent Stage is jettisoned. Finally, when the CSM re-enters Earth orbit, the Service Module is abandoned. Thus, the cone-shaped Command Module is the only part of the massive Apollo *moonshot system to actually return intact to Earth.*

spacecraft would be necessary for lunar missions. Unfortunately, the program began with a tragedy. In January 1967, an errant spark ignited the pure oxygen atmosphere in the cabin of the first Apollo capsule, killing astronauts Virgil "Gus" Grissom, Ed White, and Roger Chaffee during a routine ground test.

The American public was shocked, and at first the fire seemed a stunning setback. Indeed, it delayed the Apollo program a full year while NASA redesigned the capsule. But on October 11, 1968, America finally watched the first manned Apollo flight thunder into the Florida sky. A mere two months later, the three astronauts of *Apollo 8* spent a memorable Christmas as the first men orbiting the Moon.

On July 20, 1969, *Apollo 11* astronauts Buzz Aldrin and Neil Armstrong maneuvered their Moon lander, the *Eagle*, away from the command module piloted by Michael Collins, then down toward the Sea of Tranquility on the lunar surface. Aldrin described the descent of the *Eagle* to mission control scientists in Houston and millions of spellbound television viewers watching around the world. At the moment of touchdown, Armstrong called out: "Houston. Tranquility Base here. The *Eagle* has landed."

The Apollo program's "giant leap for mankind" didn't stop with the *Eagle*'s landing. All in all, twelve astronauts from six different missions walked the surface of the Moon. In July 1975, an Apollo docking module negotiated an historic rendezvous and two-day linkup with a Soviet *Soyuz* orbital spacecraft.

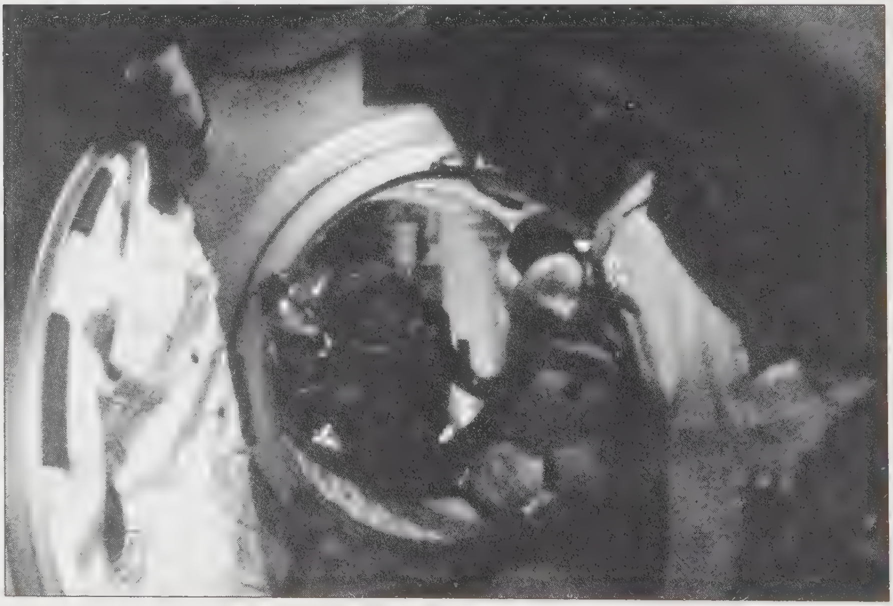


Figure 1-18
The Apollo-Soyuz Test Project *marked the first major cooperation between the primary space powers, the United States and the Soviet Union. Here, astronaut Tom Stafford shakes hands with his Soviet counterpart, cosmonaut Alexei Leonov.*

VENUS, MARS, AND BEYOND

In the early 1960s, scientists were already looking beyond the Moon to the other planets of the Solar System. In 1962, just one year after the first man went into space, the United States managed to send a scientific probe called *Mariner 2* hurtling past Venus—the first man-made craft ever to fly past another planet. And by 1967, the Soviets were receiving twenty-three minutes-worth of information from the scalding Venusian surface, where they had managed to land the probe *Venera 7*.

In 1981, *Venera 13* would show the atmosphere of Venus to be ninety times more dense than Earth's and somewhat inhospitable, composed of heavy car-

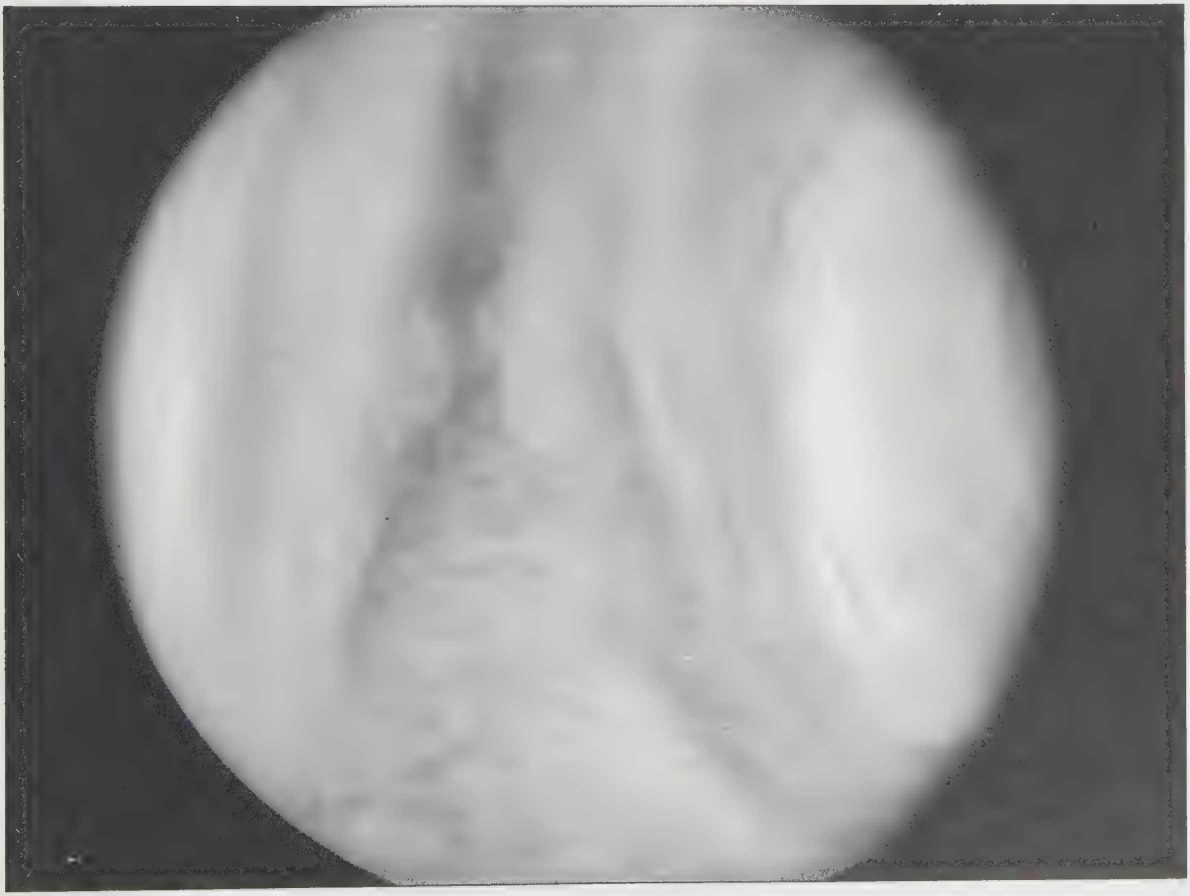
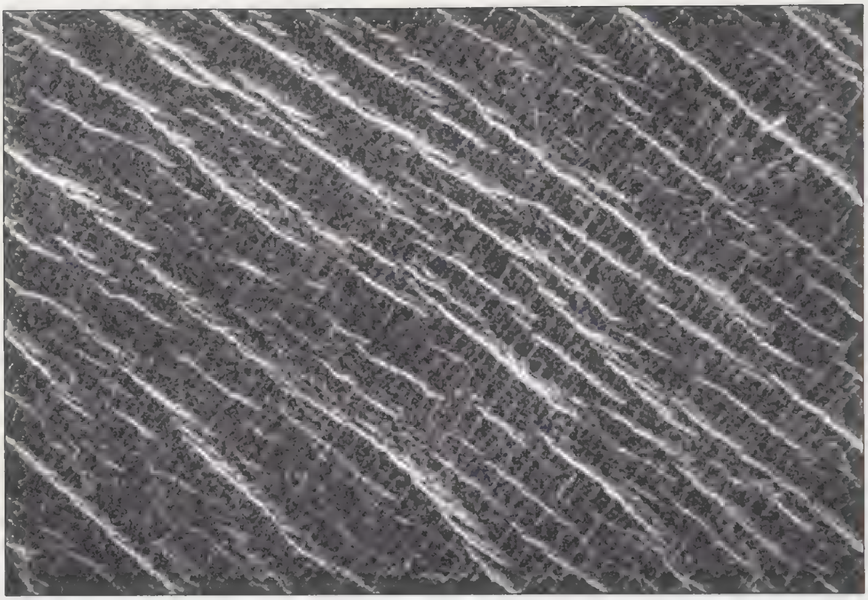


Figure 1-19 *U. S.* Mariner *and Soviet* Venera *spacecraft probed Venus in the early 1960s. The first* Mariner *shots show a planet enshrouded by a thick, swirling atmosphere.*



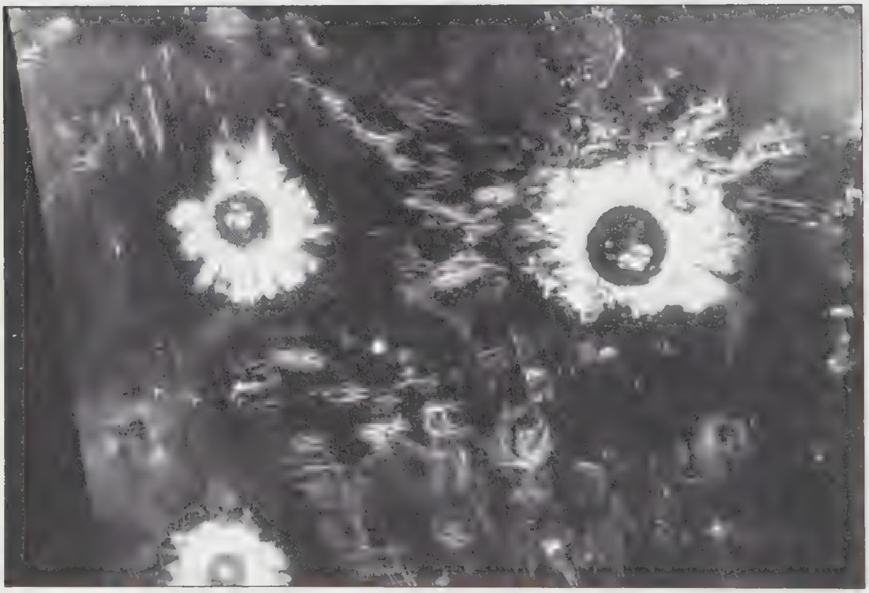


Figure 1-20
More detailed photographs of the Venusian surface by later Magellan probes reveal a bleak, hostile world of fractured plains swept by hurricane-force windstorms. Here, we can see the gouged, gridded central plains of Venus (top) *and a mosaic of impact craters* (bottom).

bon dioxide gas mixed with corrosive droplets of sulfuric acid. Upon landing, the *Venera 13* craft took pictures of a spectacularly bleak, sizzling hot landscape (900 degrees Fahrenheit!) swept by hurricane-force winds under the flickering lightning bolts of an orange sky.

The first spacecraft to reach Mars was the U.S. *Mariner 4*. Launched on

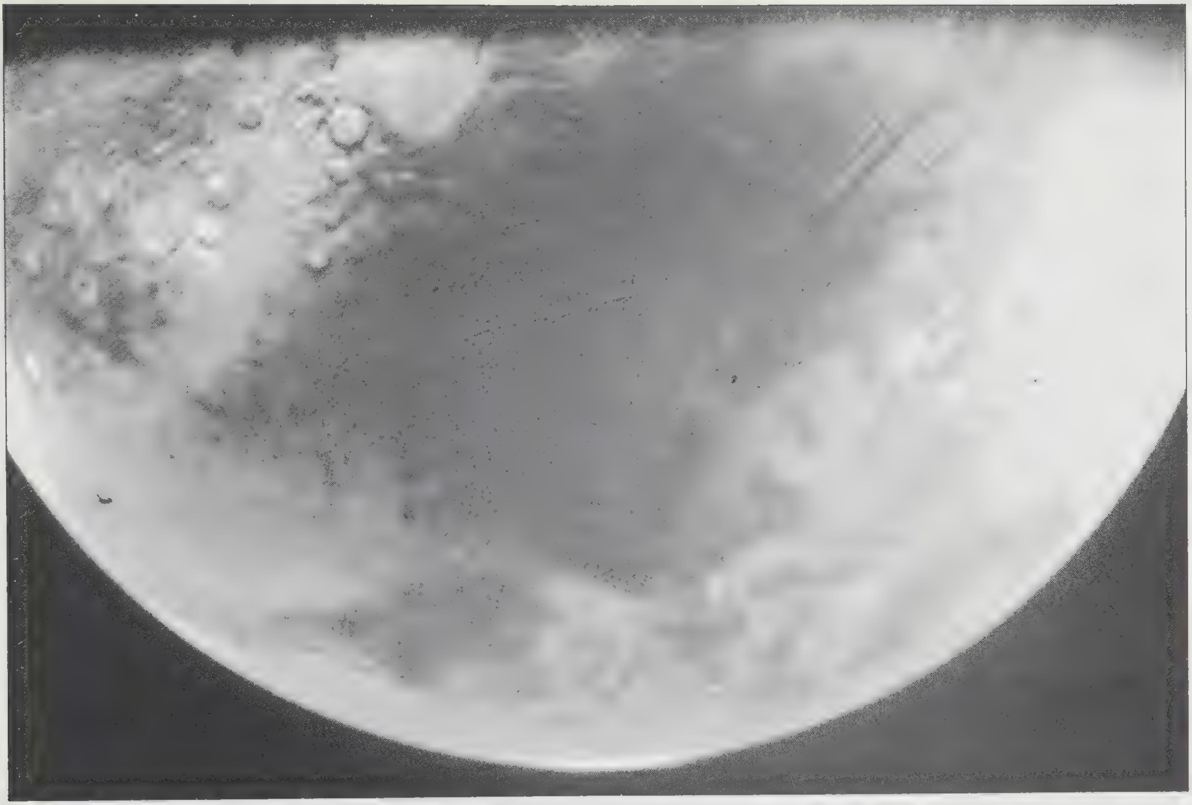


Figure 1-21 *The first* Mariner *approach shots of Mars in 1965 shattered our hopes of finding any life forms, much less civilized ones, on the red planet.* Mariner*'s pass revealed a cratered, lifeless, Moon-like surface.*

November 28, 1964, it set out on a seven-month journey to the red planet that many scientists thought might harbor life forms, or at least evidence of former life. The flyby, on July 15, 1965, produced only twenty-two photographs—but they sent a shock wave through the space science community. These pictures indicated a forbidding, rugged, well-cratered surface not unlike that of our own Moon.

Later Mariner and Viking missions revealed Mars to be actually quite different from the Moon, featuring a frigid, rocky central desert the color of rust; a chemically active but lifeless soil (no microbes); a thin atmosphere of carbon dioxide gas; two polar ice caps that contain frozen water; a gigantic rift canyon the length of North America (called Valles Marineris, which you can actually explore in *Space Simulator*); dry riverbeds and geological evidence of great

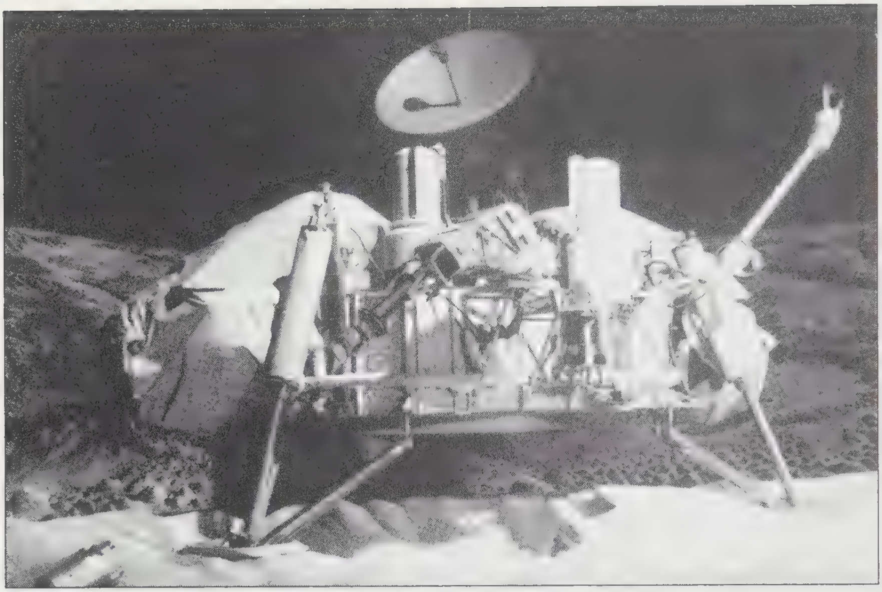


Figure 1-22a *In 1976, the United States sent two separate* Viking *probes to Mars. Each dropped landers (like the one shown here) successfully to the surface to take photographs, collect soil samples, and conduct experiments.*

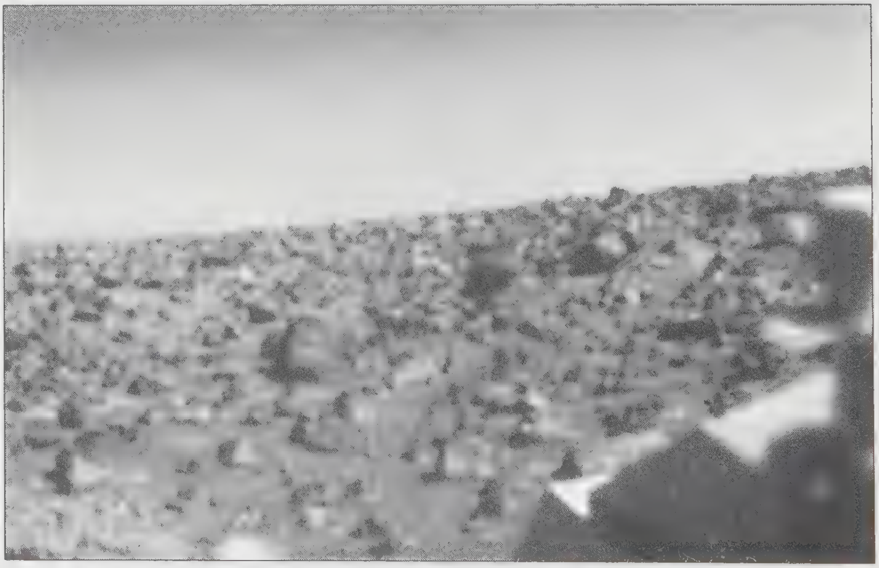


Figure 1-22b *A view of the Mars Utopian Plain from the* Viking II *lander reveals a rocky, ruddy, and very forbidding landscape. Tests of Martian soil samples show it to be chemically active, but devoid of any life forms.*

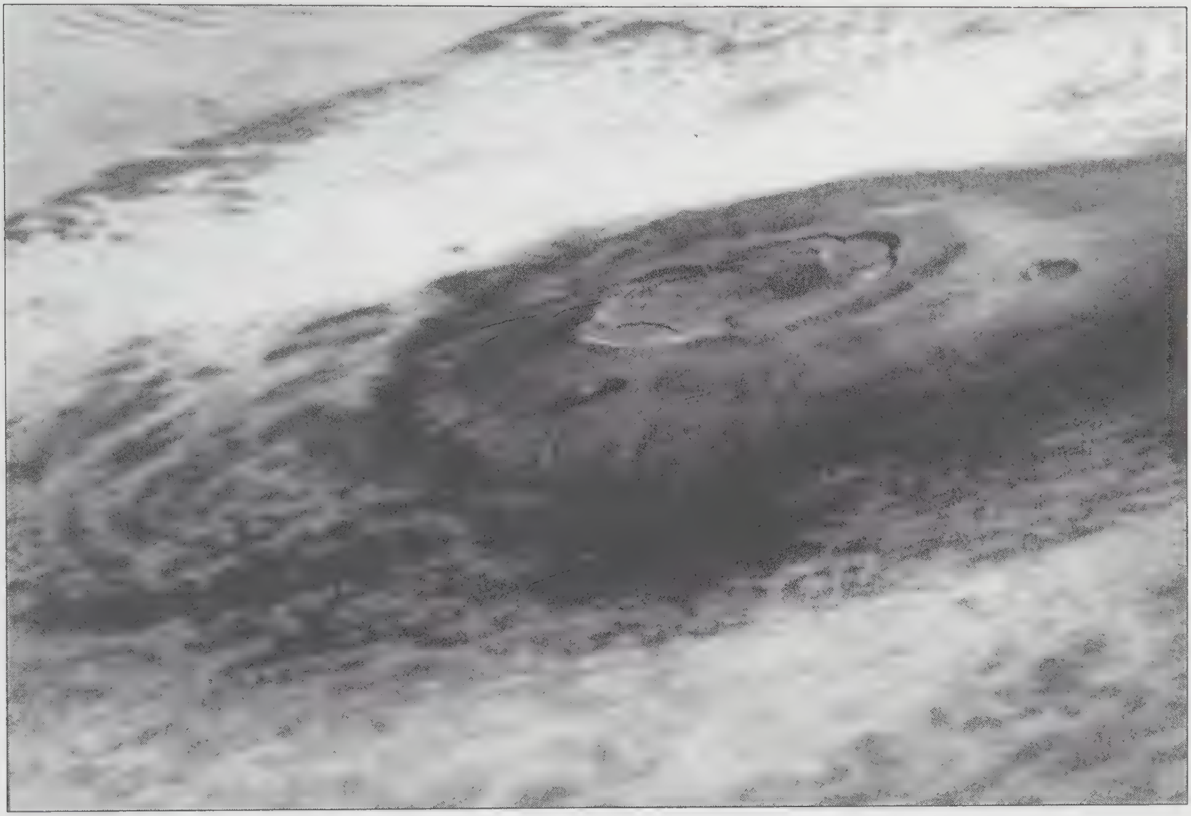


Figure 1-22c *Massive Olympus Mons rises 75,000 feet above the Martian surface. A now-extinct volcano, Olympus Mons is the tallest mountain yet found in the Solar System.*

floods; frequent dust storms; and a towering volcano, Olympus Mons, a now-extinct, 75,000-foot behemoth rising two-and-a-half times higher than Mt. Everest, the tallest mountain on Earth.

Space science gathered answers to many questions about the "inner planets"—Mercury, Venus, and Mars, our closest neighbors. But what about the farther planets? In 1972, NASA launched *Pioneer 10* toward Jupiter, the fifth planet of the Solar System. It would be a two-year trip; at its closest point, Jupiter lies almost 400 million miles from Earth. In addition, *Pioneer 10* would have to make a possibly treacherous crossing through 270 million miles of drifting, rocky debris—the asteroid belt between Mars and Jupiter. Some astronomers believe the chunks of rock in this area to be the remains of another planet, one possibly destroyed by a celestial collision or some other phenomenon. Others see it as protoplanetary material—"building blocks" for a planet that, for some reason, never got its act together.

Whatever the case, *Pioneer 10* made it through without even a remotely close encounter. Then, in its Jupiter flyby, the probe beamed back an awe-inspiring look at the spectacular gas giant. Jupiter's swirling atmosphere harbors massive 300 MPH storms which generate bolts of lightning so large, a single strike could lay waste to New York City. Indeed, Jupiter's famous Great Red Spot

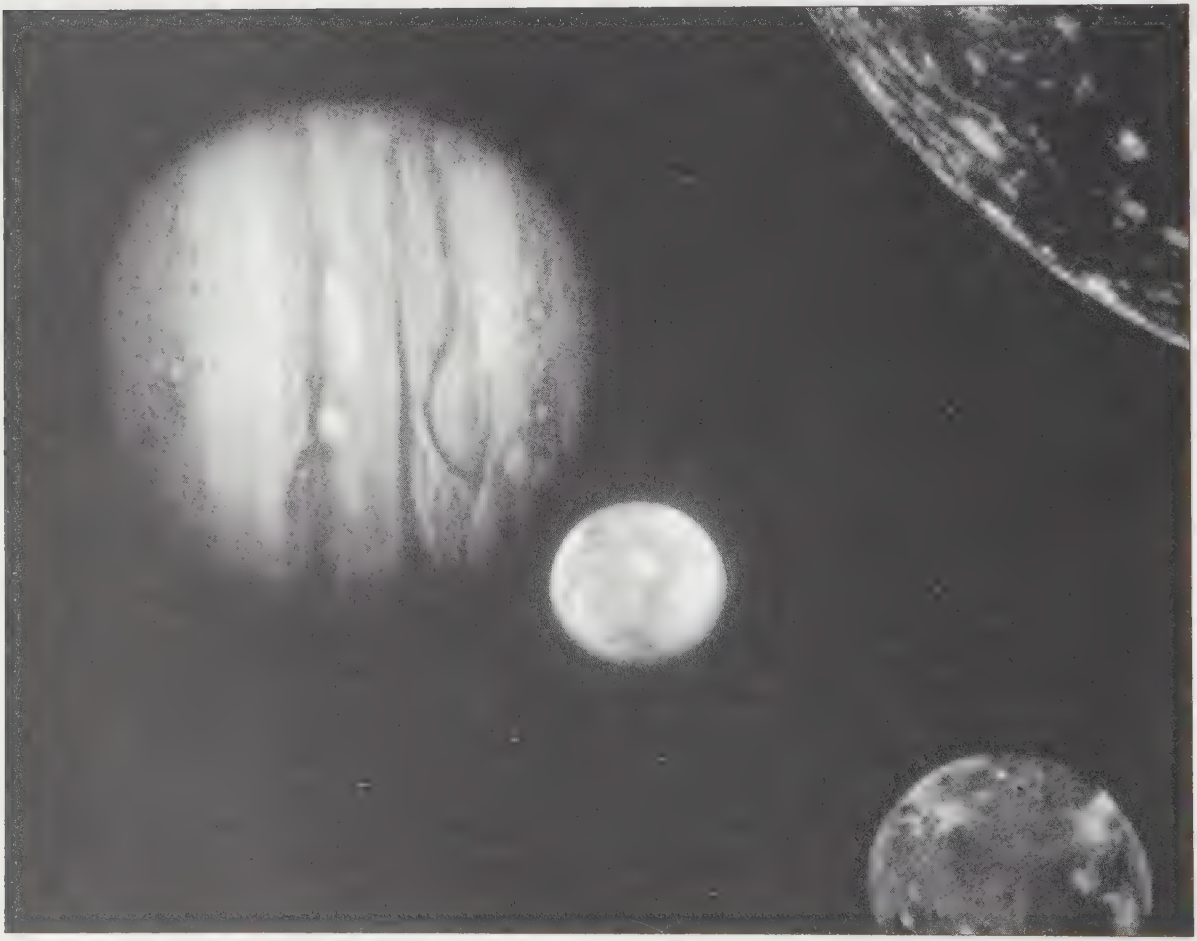


Figure 1-23 *This spectacular photo montage captures Jupiter and all four of the "Galilean" moons.* From upper left: *Io, Europa, Ganymede, and Callisto.*

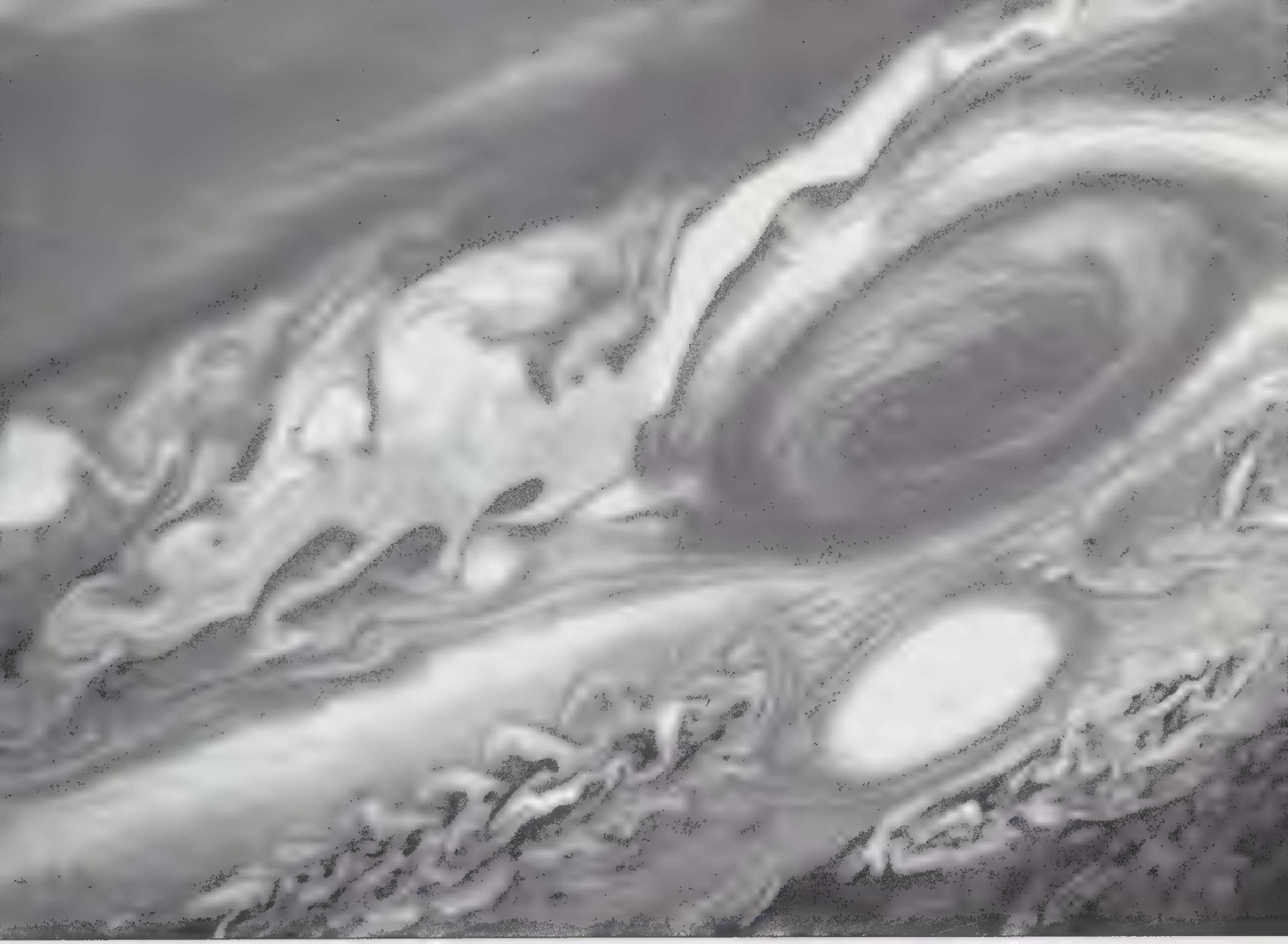


Figure 1-24 *This* Voyager *closeup features Jupiter's swirling gas clouds and Great Red Spot, an immensely powerful 25,000-mile-wide hurricane that has been raging across the planet's surface for centuries.*

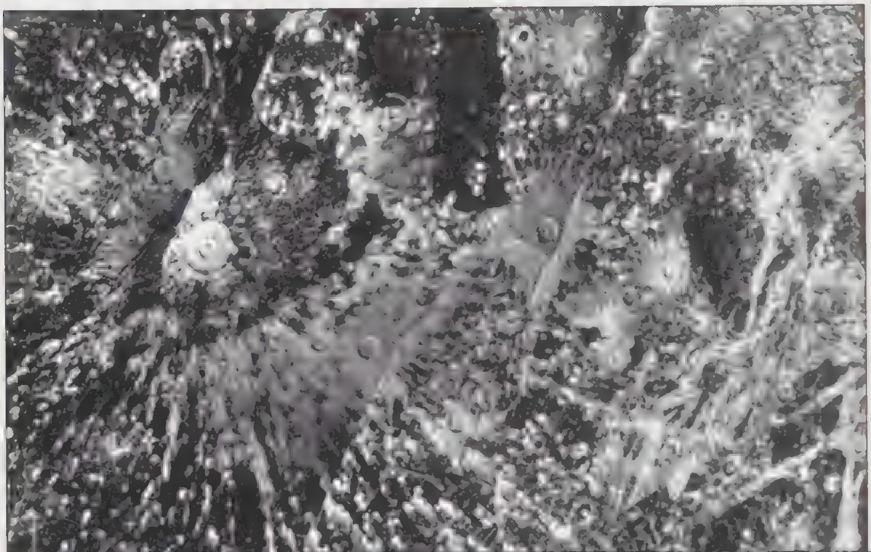
is a hurricane of almost unimaginable proportions (25,000 miles wide!) that has been raging across the planet's liquid hydrogen seas for centuries.

The next generation of U.S. space probes, a pair of hardy craft called *Voyager 1* and *2*, began journeys to Jupiter in 1977. These two explorers provided a closer look at Jupiter, and also examined its four "Galilean moons"—the four moons discovered by Galileo on January 7, 1610. Ganymede, the biggest moon in the Solar System, is a cratered ice planet covered by a crisscrossing system of grooved bands. Its dark twin Callisto, another ice world, is heavily pockmarked by impact craters. Europa features a capillarylike system of blood-red fractures on its icy surface.

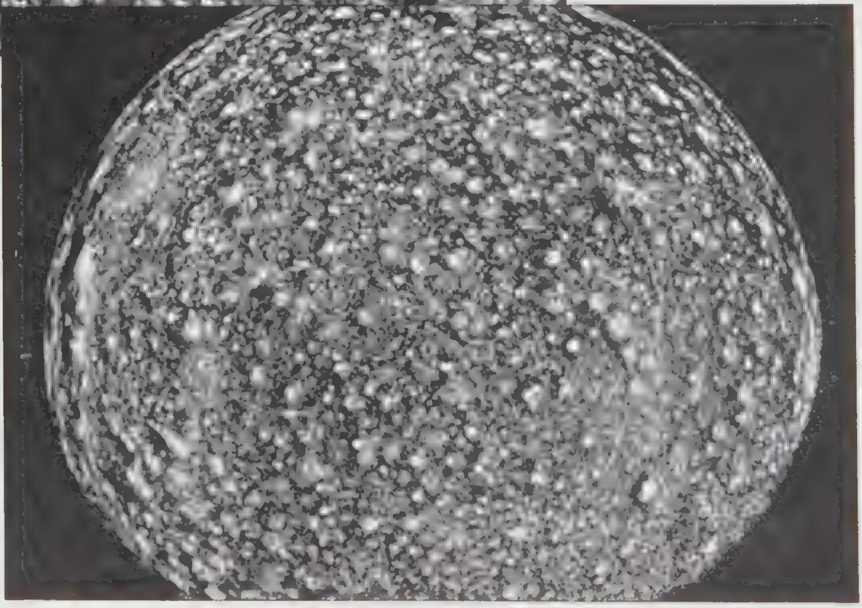
Last but not least, ruddy Io, closest moon to Jupiter, provided an unexpected wonder. Unlike the other moons, Io featured a smooth surface, which suggested

The "Galilean Moons" of Jupiter

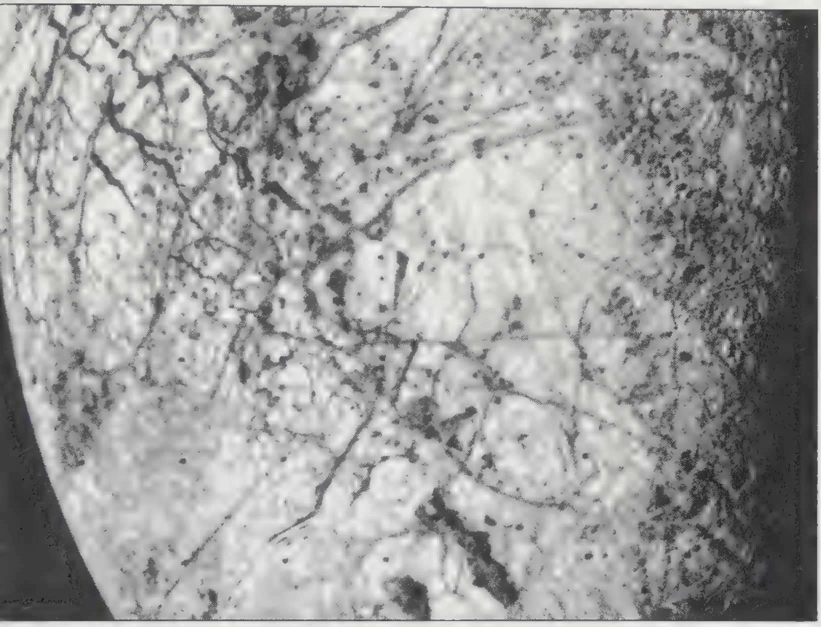
On January 7, 1610, the great Italian astronomer Galileo looked at Jupiter through his newly invented telescope and discovered the four largest moons of the planet. Today we know that Jupiter has at least 17 moons, but the four discovered by Galileo are the most prominent, and perhaps most interesting as well.



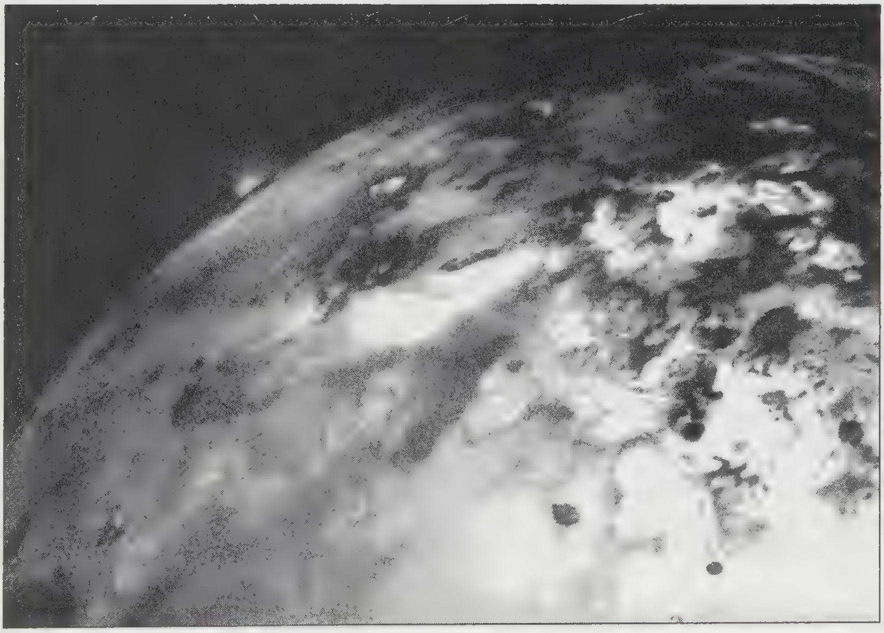
The icy surface of Ganymede has been gouged into a strange and complex system of grooved bands that resemble crisscrossing highways.



This photomosaic of dark Callisto, taken from a distance of 245,000 miles, reveals a battered surface, pockmarked by huge impact craters.



Seen from 150,000 miles, Europa features a relatively smooth surface fractured into a system of intricate cracks that resemble capillaries of blood, or a cracked eggshell.



Voyager 1*'s camera here records the most dramatic moment ever captured by a planetary probe. As* Voyager *swings past Io, it beams back photographs of a massive volcanic eruption in progress.*

some weathering process. But Io was too small to hold an atmosphere for "weather." What else could render a planetary face so smooth?

As *Voyager 1* flew closer, its cameras recorded the reason—a spectacular volcanic eruption, its towering plume rising 175 miles high. Scientists eventually pinpointed eight other active volcanoes on Io, each constantly erupting and spilling lava across the surface, filling in any craters or fissures that might exist. It was an exciting and very significant scientific find. Io's active volcanoes were the first seen anywhere beyond Earth.

Note: To take your own breathtaking look at the Galilean moons of Jupiter, I highly recommend that you try "Riding the Galilean Carousel," the mission adventure outlined in Chapter 13 of your *Star-Pilot's Guide.*

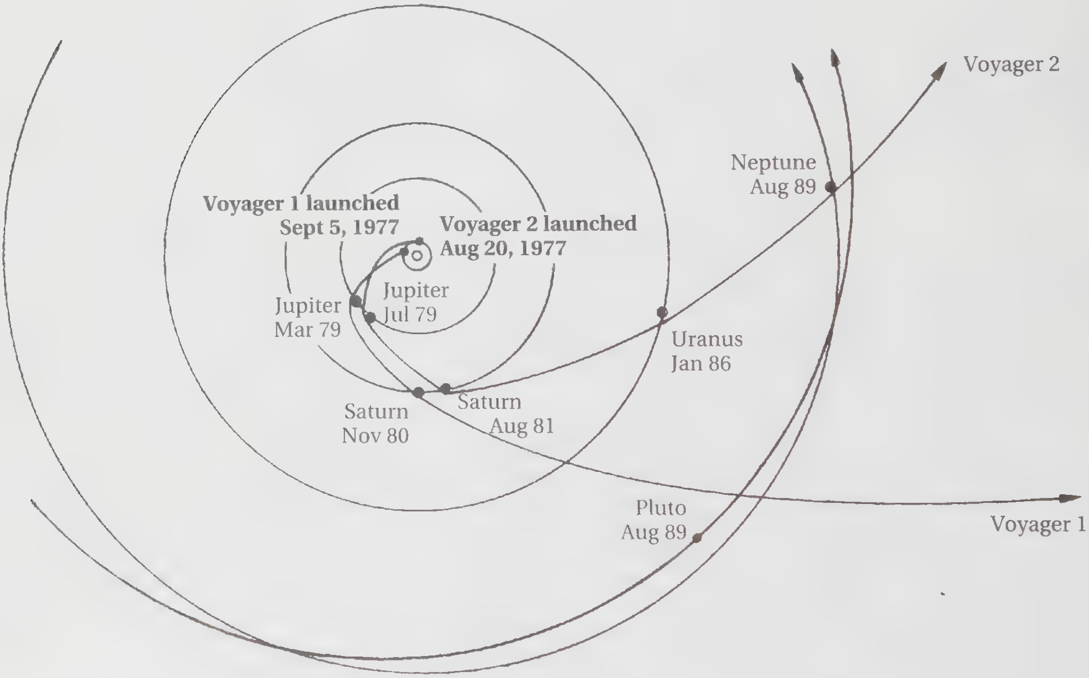

Voyager 2
Neptune
Aug 89
Voyager 1 launched
Sept 5, 1977
Voyager 2 launched
Aug 20, 1977
Jupiter
Jul 79
Jupiter
Mar 79
Uranus
Jan 86
Saturn
Aug 81
Saturn
Nov 80
Pluto
Aug 89
Voyager 1

Figure 1-25 Gravity Well at Work. *This diagram traces the routes of the two* Voyager *spacecraft launched in 1977. Note how scientists used Jupiter's gravity well to arc the trajectory of each probe toward Saturn. Note also how Saturn's gravity subsequently bent the trajectory of* Voyager 2*, sending it on to a rendezvous with Uranus, then Neptune.*

Both *Voyagers* eventually continued on from Jupiter to Saturn. *Voyager 1* arrived in 1980 and gave us our first close look at Saturn's stunning, exquisitely braided rings. The craft also ventured within 5,000 miles of the largest Saturnian moon, Titan, a fascinating world that features a thick nitrogen atmosphere not all that different from Earth's, cold seas of liquid methane, and a surface temperature of about -290 degrees Fahrenheit. *Voyager 2* followed in *Voyager 1*'s footsteps, then kicked outward to astounding examinations of distant Uranus (1986), then Neptune (1989).

For a stunning tour of the planets of the Solar System, try the Tutorial in Chapter 4.

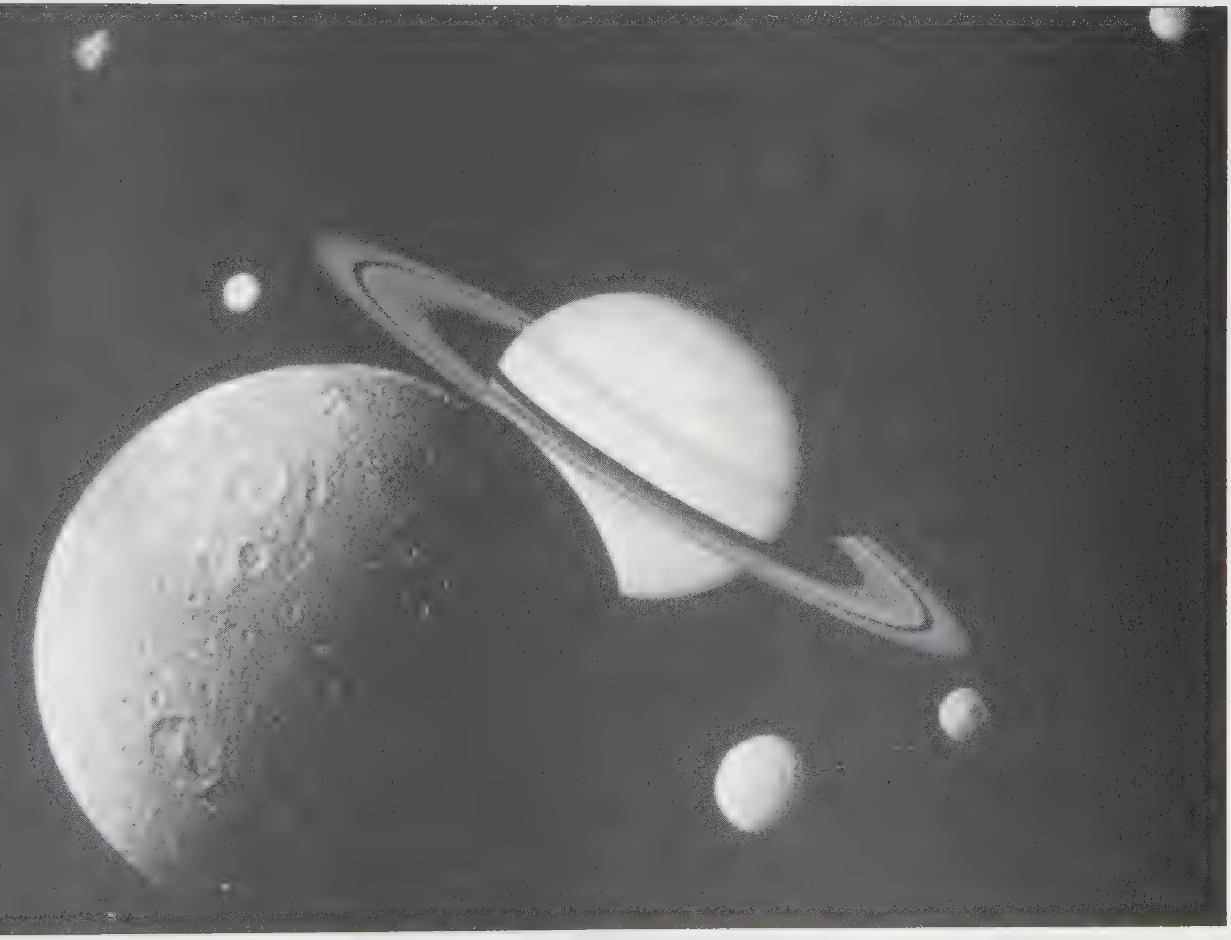


***Figure 1-26** A breathtaking look at the Saturnian system, including a few of Saturn's twenty-one moons.* Counterclockwise from upper left: *Dione, Tethys, Mimas, Enceladus, Rhea, and Titan.*

Figure 1-27 *Here's a closeup look at Saturn's remarkably intricate ring system.* Voyager *found tens of thousands of individual rings, composed of perhaps a trillion individual ice chunks—most about the size of beach balls, some as large as a house, some just tiny specks.*

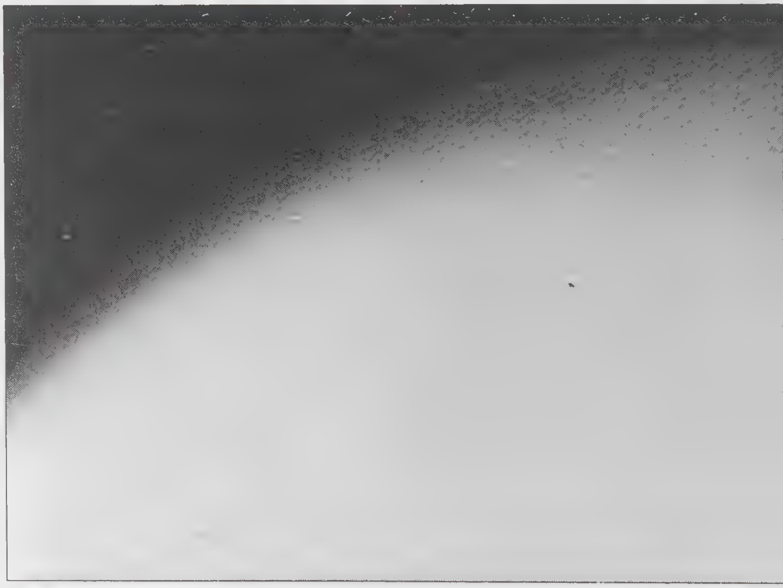


Figure 1-28 *This shot of Titan from a distance of 435,000 miles reveals a thick, telltale haze which indicates the presence of an atmosphere.*

WORKSTATIONS IN SPACE: *SALYUT* AND *SKYLAB*

In the race to put an orbiting space station in the sky, the Soviet program, as often before, was the winner. On April 19, 1971, the first *Salyut* roared into space, where it supported space research for 2,800 orbits until it flamed into the Earth's atmosphere the following October. Subsequent *Salyut* stations, designed for two to three cosmonauts, quickly followed.

On May 14, 1973, the United States launched its *Skylab* space station into orbit. One primary objective was to investigate how well the human body could adapt to long stretches in space. Before *Skylab*, the longest American flight had been the fourteen-day flight of *Gemini 7* in 1965. NASA physicians who examined astronauts James Lovell and Frank Borman after that mission discovered an alarming physical deterioration. Five years later, a crew of Soviet cosmonauts

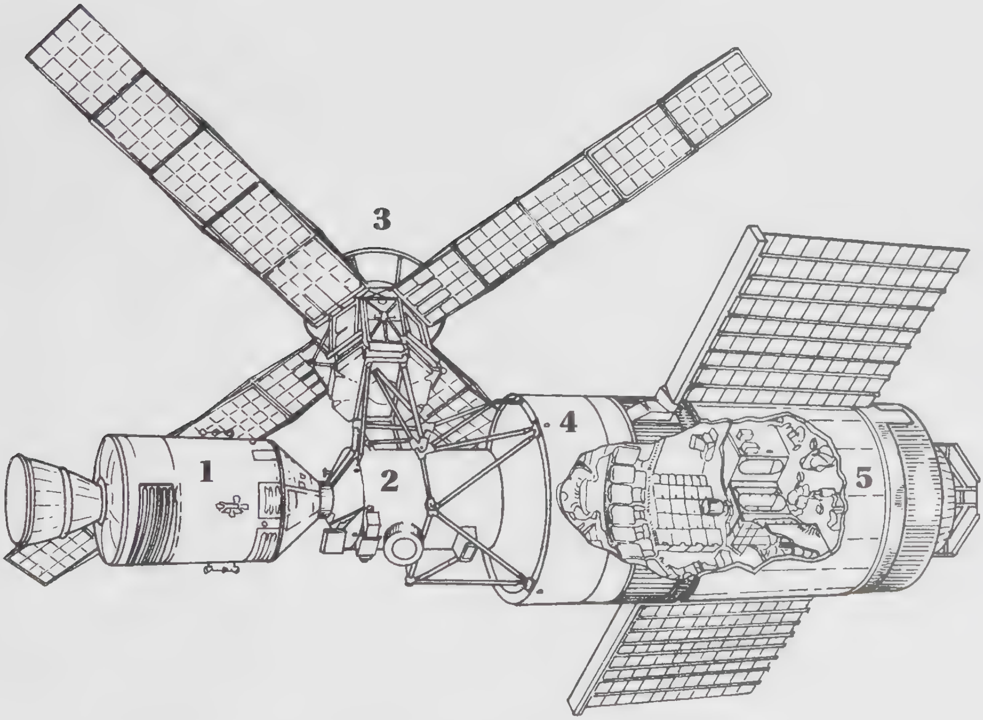


Figure 1-29 *Here's the 170,000-pound* Skylab *space station docked with an* Apollo *spacecraft (1) via the Multiple Docking Adapter (2). On top is the Apollo Telescope Mount (3). Just off the docking adapter is a large (10 x 17-foot) airlock with an attached instrument unit (4). Finally, flanked by solar panels sits the roomy, 21 x 48-foot Orbital Workshop (5). (One of the two solar panels was torn off during* Skylab*'s launch.)*

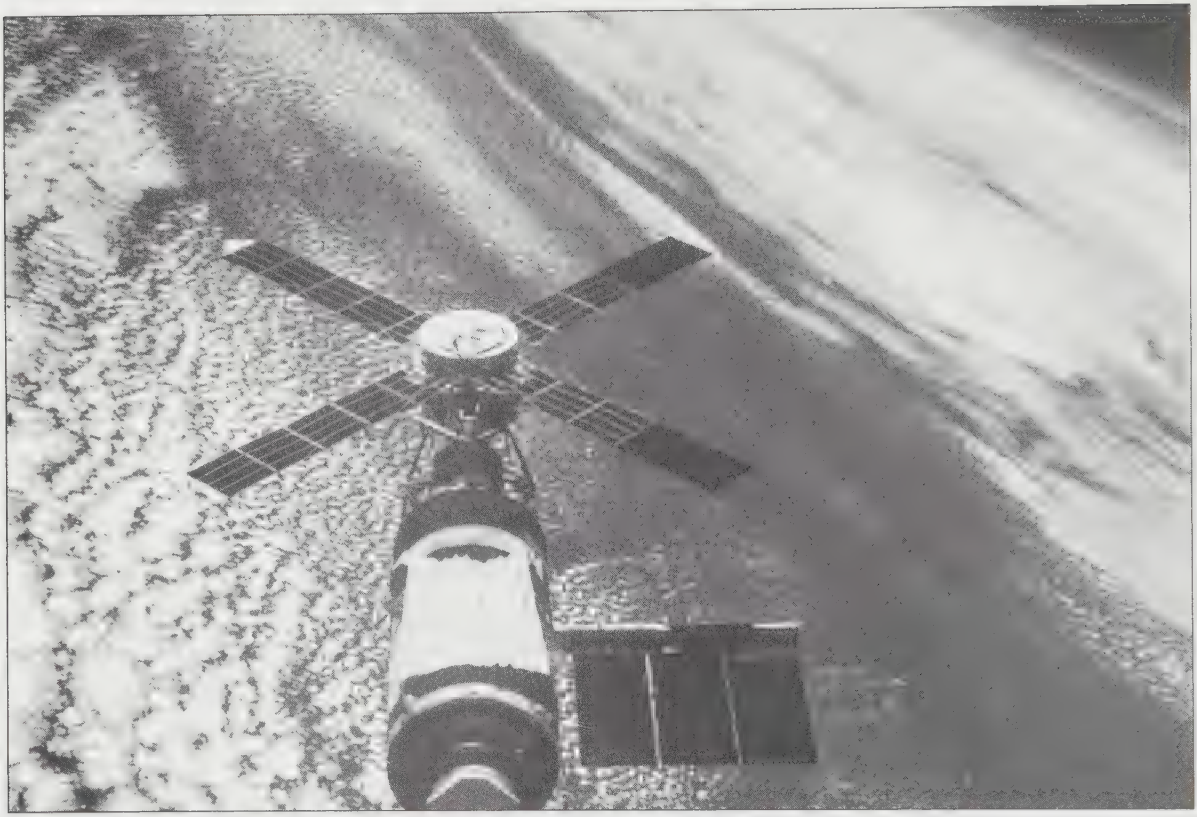


Figure 1-30 *The* Skylab *orbiting laboratory was used by three separate crews in 1973 and 1974. Note the bank of solar panels extending to the right of the central cylinder; a second bank of panels extending left was torn away during* Skylab*'s launch.*

who spent eighteen days in orbit returned so debilitated that they had to be carried from their spacecraft after it landed.

Obviously, things didn't look good for extended space travel. But the *Skylab* experience was a radical departure for spacefaring astronauts. Its enormous living area was as big as a three-bedroom house. Compare *Skylab*'s 12,000 cubic feet with the mere 210 cubic feet in the Apollo command module, or the "Spam in a can" confines of the 4-by-5-foot *Mercury* capsule. The work area alone measured 48 feet long by 21 feet wide.

Although damaged during liftoff, the station was repaired eleven days later by the crew of the first *Apollo* docking craft. That crew—Pete Conrad, Paul Weitz, and Joseph Kerwin—spent twenty-eight days aboard *Skylab*, conducting experiments and setting a new record for time in space. They also returned in far better physical condition than the *Gemini 7* astronauts and Soviet cosmonauts. Conrad, in particular, was robust and healthy; he walked and felt better than he did after his ten-day *Apollo 12* mission!

The reason, NASA discovered, was Conrad's vigorous use of the stationary exercise bike aboard *Skylab*. The other two astronauts used it to lesser degrees, and their postflight conditions correlated directly with their regimens. Due to these findings, the NASA team of physicians made serious exercise a requirement on subsequent Skylab missions. The results were dramatic—despite ever-longer stays, the crews returned in increasingly better condition.

In all, three separate Apollo crews managed to spend a total of 171 days in *Skylab* before its declining orbit finally scattered it in fiery pieces over the Australian desert.

While the American space station program went into limbo after *Skylab*, the Soviets continued to systematically develop their Salyut program throughout the 1980s. In 1982, a seven-month mission aboard *Salyut 7* revealed another concern of extended space living—apparently, the crew annoyed one another. Due to a short group training period, personality conflicts didn't appear until well into the actual mission. As a result, the next Salyut mission, an eight-month stay in 1984, was preceded by a much-improved "team-building" process.

The latest development in this area is the Russian *Mir* space station. The first *Mir*, launched in 1986, is a spacious 108 feet long, with six full docking ports for resupply craft. In 1986-87, cosmonaut Leonid Kizim spent a full year aloft, splitting time between the new *Mir* station and the old *Salyut 7*.

THE SHUTTLE ERA

After the Apollo Moon landings and the short-lived *Skylab* experiment, NASA found itself doing some soul-searching. What should be the next goal of the U.S. space program?

Public interest in space travel was waning. Ironically, NASA's steady stream of successes had reduced the spectacle of a space shot to an almost common, undramatic event. Economic pressures began to assert themselves as well. Inflation, the energy crisis, and the stagnant economy of the late 1970s brought calls for budgetary restraint. Some even questioned whether NASA had outlived its grand purpose.

NASA's answer to all this was a twin focus on utility and reusability in the form of an "orbital truck" that could shuttle payloads into the sky, then return, again and again. Officially labeled the Space Transportation System (STS), this new winged craft became more popularly known as the *space shuttle.*

Although many designs floated through the agency, scientists ultimately settled on a system that relied on a standard set of rocket boosters to get the shuttle aloft. Two minutes after liftoff, a pair of solid-fuel rocket boosters would separate from the shuttle system and parachute back to Earth, to be used again. Only a large external liquid-fuel tank would be disposable, jettisoned about eight minutes into the flight. (For a detailed look at a shuttle flight, see Chapter 2.)

The first fully operational system, *Columbia*, roared into the sky above Cape Canaveral on April 12, 1981—twenty years to the day after Yuri Gagarin became the first person in space. Later that day, astronauts Robert Crippen and John Young piloted the shuttle to a perfect landing at Edwards Air Force Base in the California desert. Except for the loss of a few heat-resistant tiles on the underbody, the craft came through unscathed.

Thus was born a new type of spaceflight program, a program that would log two dozen flawless launches using two different STS vehicles. It was an admirable record, but it ended on January 28, 1986, the darkest day in the history of spaceflight.

On that morning, the shuttle *Challenger* rose from the launch pad on a cascade of searing exhaust, carrying seven astronauts, including a schoolteacher named Christa McAuliffe. It flew magnificently for about a minute down the

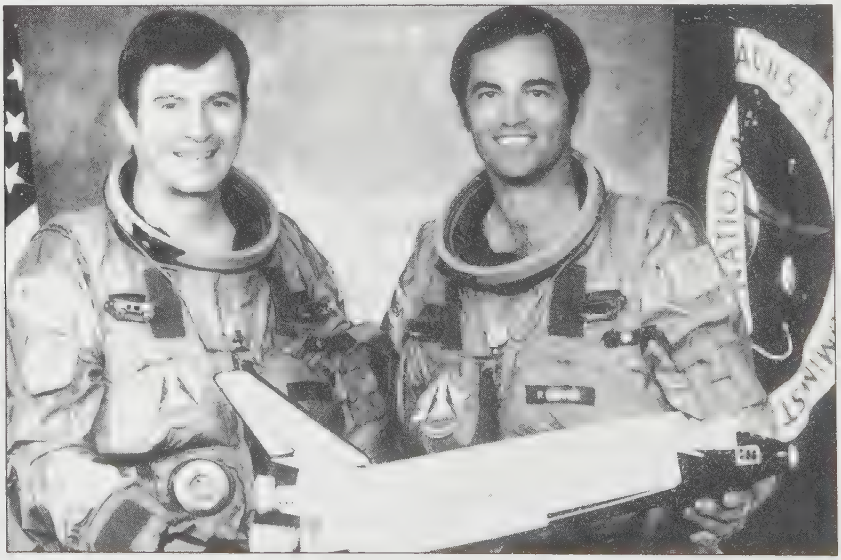


Figure 1-31
Astronauts John Young and Robert Crippen where scheduled to crew the shuttle Columbia *as it made the maiden voyage of NASA's new Space Transportation System (STS) program, initiating the era of reusable spacecraft.*

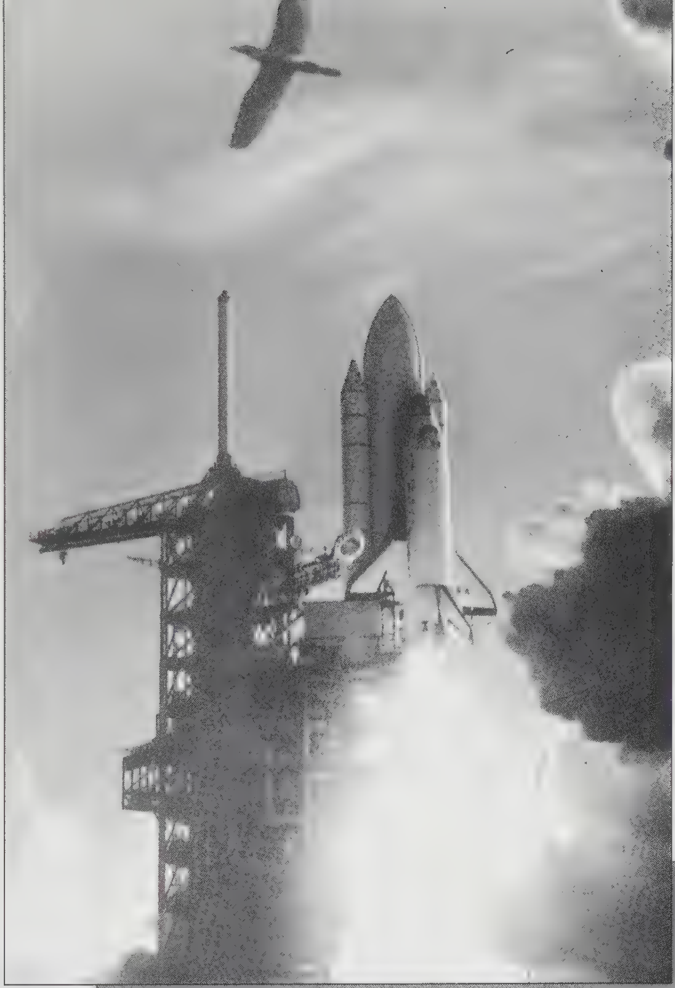
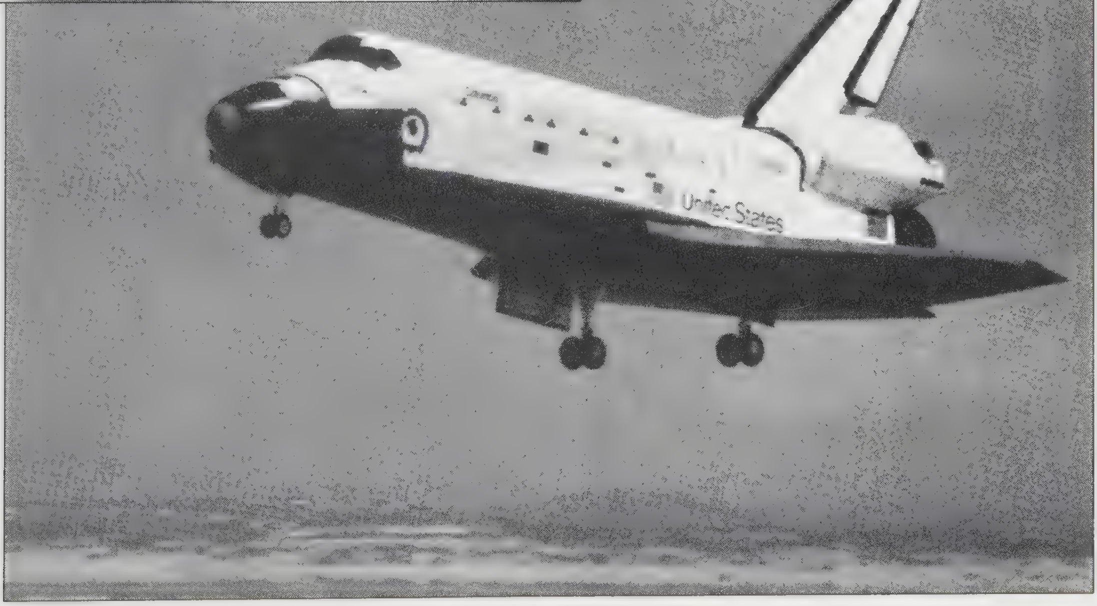


Figure 1-32 *"Bird's away!" Both the 2,000-ton* Columbia *and a startled seagull lift off on April 12, 1981—exactly twenty years after Yuri Gagarin became the first human being in space.*

Figure 1-33 *Pilot John Young guides the* Columbia *to a perfect completion of its two-day inaugural mission, landing at Edwards Air Force Base in the California desert.*



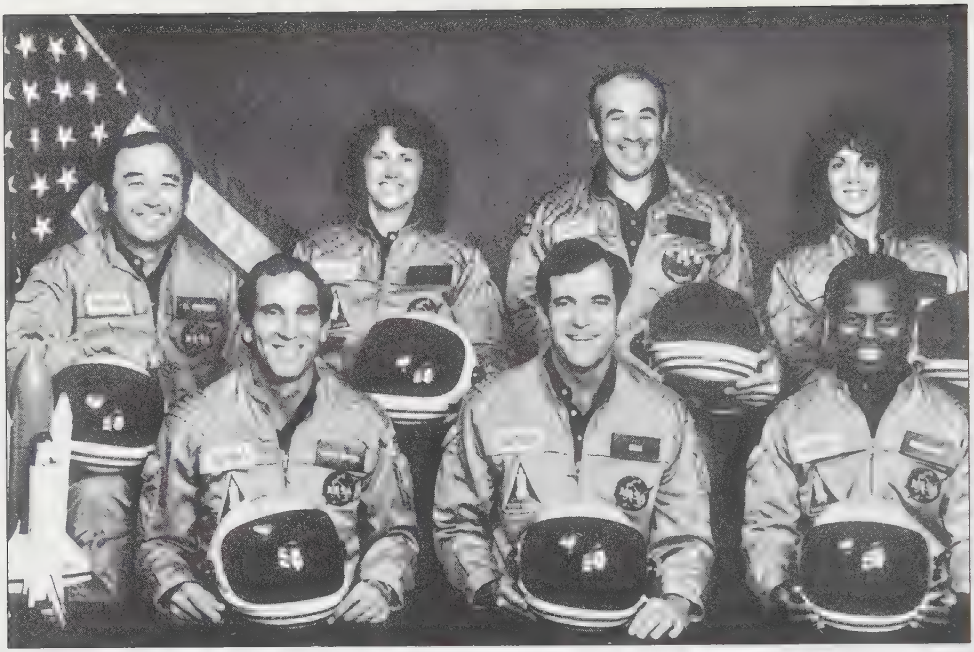
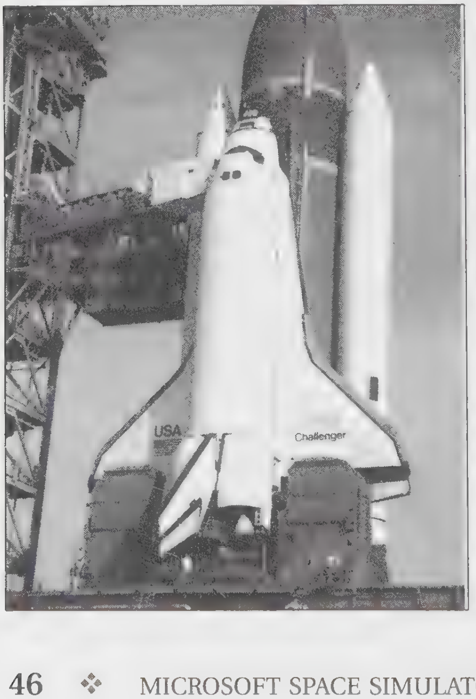


Figure 1-34 *The ill-fated crew of STS 51-L, who flew aboard the* Challenger *in January of 1986:* (Left to right, front row) *Pilot Michael J. Smith, Commander Francis "Dick" Scobee, Ronald McNair.* (Left to right, back row) *Ellison Onizuka, Christa McAuliffe, Gregory Jarvis, Judith Resnick.*



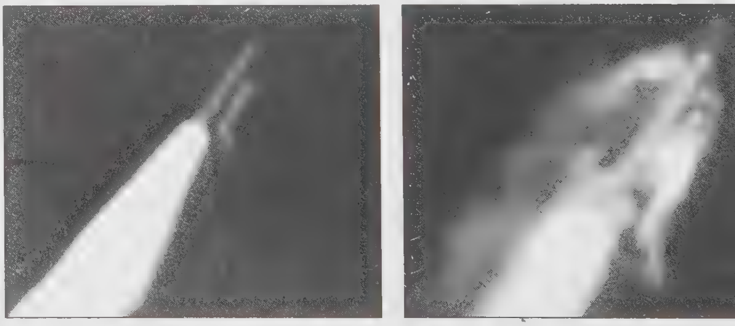


Figure 1-35 Left: *The Space Shuttle* Challenger *sits on a Cape Canaveral launch pad in preparation for the tragic launch of STS 51-L.* Above: *Barely a minute into its flight, the* Challenger *explodes over the Atlantic, killing all seven astronauts on board.*

Atlantic range, and then exploded in a horrifying fireball. All seven astronauts were killed. Close-up TV footage showed a small flicker of flame burn through a rubber O-ring seal in one of the solid rocket boosters, then ignite the external fuel tank.

The nation mourned, and the shuttle program was put on hold for almost three full years. But by the end of 1988, the shuttle program was back in the skies, and racking up brilliant successes. Perhaps the most notable was the dramatic in-space repair of the myopic Hubble space telescope in December 1993. Astronaut-technicians installed corrective lenses into the orbiting observatory, which is now beaming back images of stunning clarity. These include pictures of the environs of the first-ever confirmed black hole, located at the heart of the giant galaxy M87, more than 50 million light-years away.

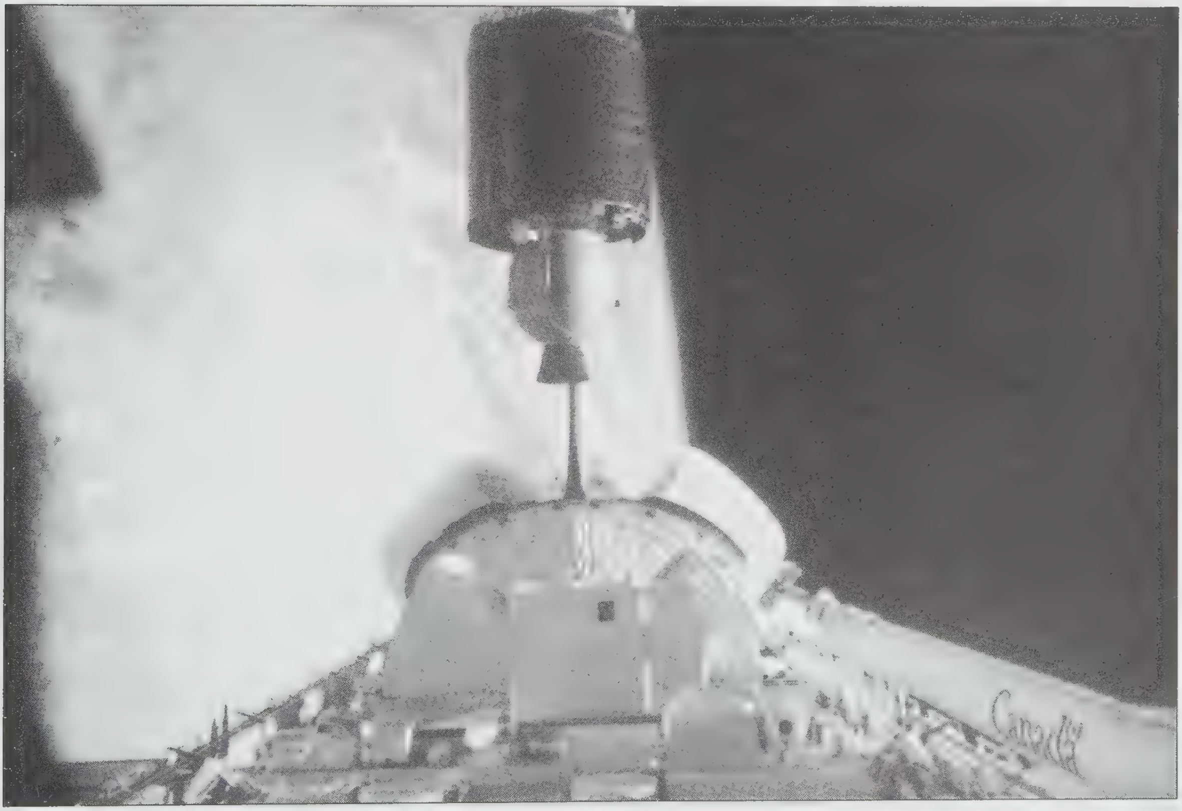
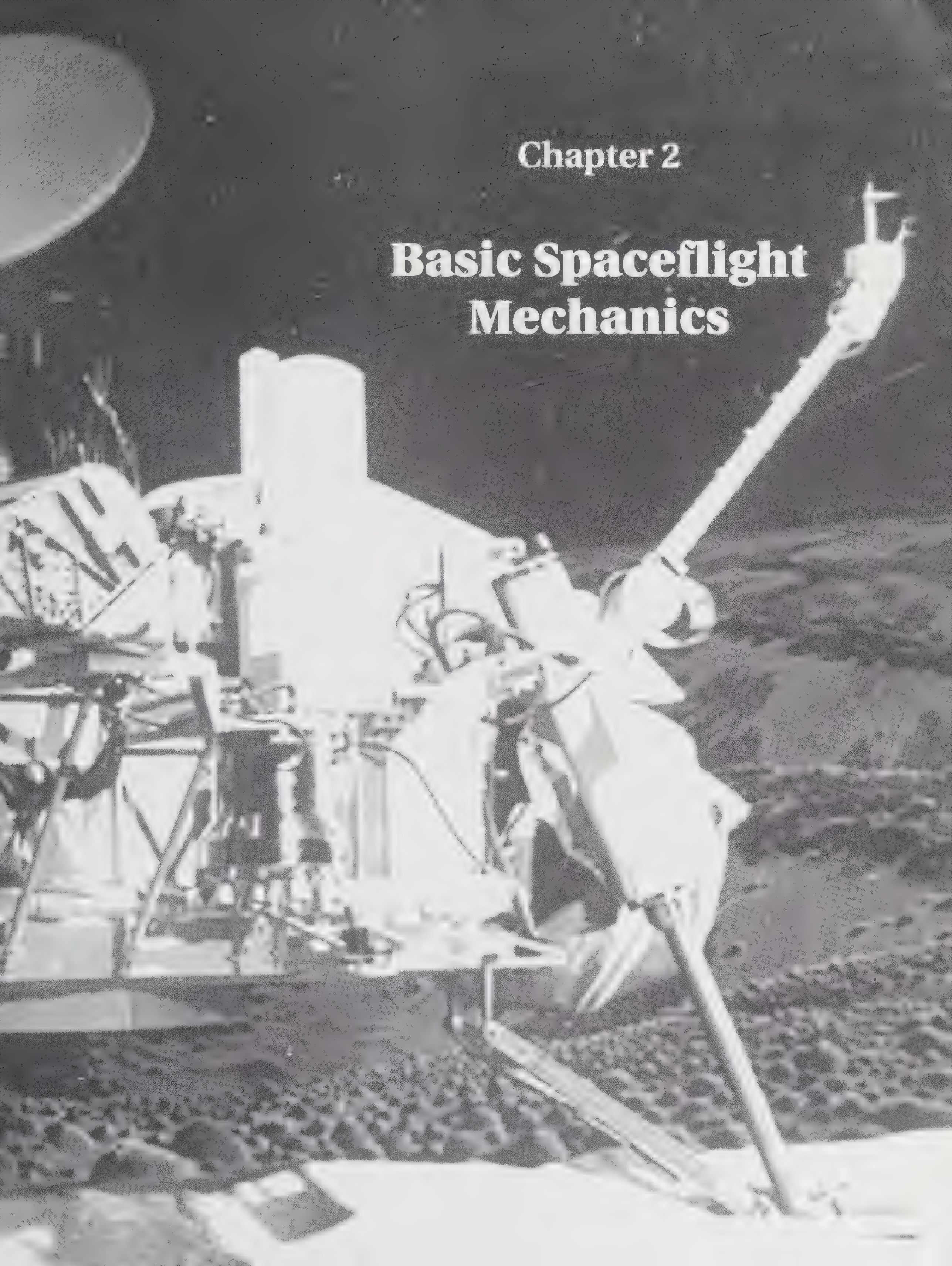


Figure 1-36 *Three years after the* Challenger *disaster, a much safer space shuttle program launched back into operation, regularly deploying satellites such as this one from its cargo bay.*

Chapter 2

Basic Spaceflight Mechanics



"Man is a frail creature of the ground."

—Roy Gallant in *Man's Reach for the Stars*

Where is space? One obvious answer is "up." But more precisely, where does space begin? Most scientists would agree that the boundary of space is at an altitude of 100 miles. Here, the atmosphere has thinned to about one-trillionth its density at sea level. This is the lowest that low-orbiting satellites can go and still remain operational.

Now we know where space is. The next question is, how do we get there? Until some unforeseen development allows us to bend gravity to our will, the answer will remain "rocket propulsion."

HOW A ROCKET WORKS

Any kind of rocket propulsion system relies on the rapid expansion of gases caused by the controlled burning of fuel within some sort of engine compartment, and on Newton's third law of motion, which states that for every action there is an equal and opposite reaction.

In order for rocket fuel to burn, it must be combined with an oxidizer—oxygen or other substances that usually contain some form of oxygen. A jet engine simply uses oxygen from the Earth's atmosphere as its oxidizer for burning fuel. A spacefaring rocket, however, must carry its own oxidizer, since there is no air in outer space.

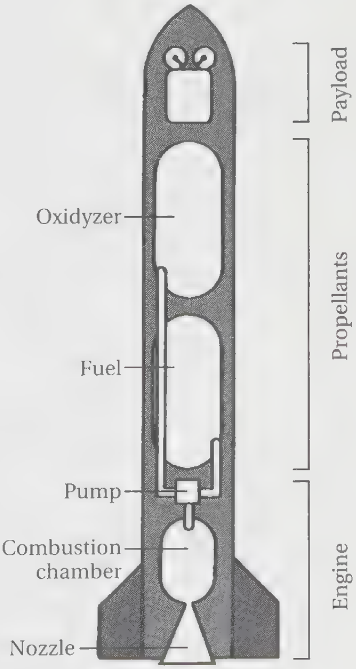


Figure 2-1 *A rocket's propellants—*fuel *and* oxidizer*—mix in a combustion chamber. A spark or chemical reaction ignites them to create rapidly expanding gases. This exhaust rushes out a nozzle, pushing the rocket in the opposite direction.*

The fuel (kerosene, alcohol, or liquid hydrogen, a very light substance) and the oxidizer (usually liquid oxygen) are called the rocket's *propellants.* The propellants are pumped into a combustion chamber, where they are ignited by a spark or a chemical reaction. (Many propellants simply ignite upon contact with one another.) The subsequent burn transforms the propellants into rapidly expanding hot gases.

The engine vents these gases (the "action" of Newton's third law) out of the combustion chamber through an exhaust nozzle aimed in one direction. Then the "equal and opposite reaction" pushes the vehicle in the opposite direction.

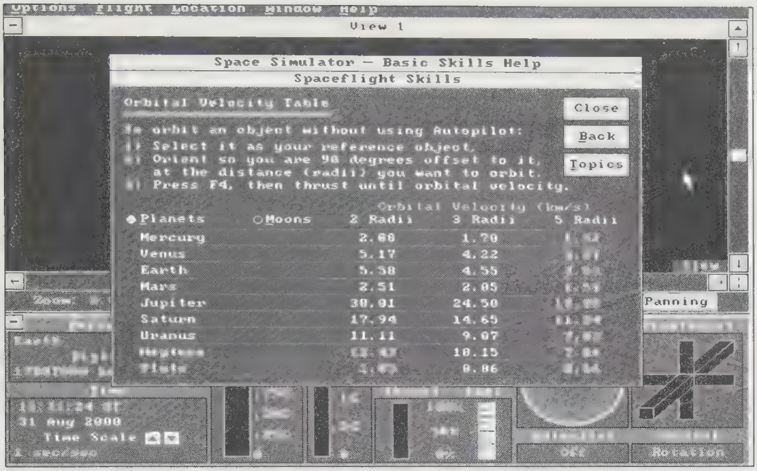
Orbital Velocity

Another of Newton's laws of motion, his first law, states that a body in motion will tend to remain in motion unless acted upon by some force. So once a force such as rocket propulsion pushes a body—say, a rocket—to a certain velocity in a certain flight path, the body will continue at that velocity in that path forever unless some force (gravity, atmospheric friction, or a deceleration burn, for example) exerts itself on the body.

This is the fundamental principle underlying orbital mechanics. Any stable orbit of a body around a central object (such as the Moon around the Earth) constitutes a perfect balance between the central object's gravitational pull and the momentum supplied by the orbiting body's velocity. For example: The Moon is a captive of Earth's gravity. Yet it does not crash into the planet because the Moon's velocity allows it to pull away from the Earth with a force equal to Earth's gravity. In this perfect balance, the orbiting body's speed is known as *orbital velocity.*

Note that the gravitational pull of a central object such as Earth decreases with distance. Therefore, orbital velocity decreases with distance. For example, the Moon is about 240,000 miles from Earth. It maintains its orbit with a velocity of about 2,200 MPH. But the standard Earth orbit of a manned orbital mission is only about 150 to 250 miles high. To maintain an orbit at this distance, an object must travel much faster—about 17,500 MPH. A space station orbiting at an altitude of 1,075 miles would only need to travel 15,840 MPH to maintain its orbit.

One of the nice Help features of *Space Simulator* is a handy Orbital Velocity Table (shown in Figure 2-2) for the nine Solar System planets you'll want to orbit during your explorations. You'll notice that the velocity requirement decreases as the distance (number of radii) from the planet increases.



Orbital Velocity Table

To orbit an object without using Autopilot:
1) Select it as your reference object.
2) Orient so you are 90 degrees offset to it, at the distance (radii) you want to orbit.
3) Press F4, then thrust until orbital velocity.

● Planets	○ Moons	Orbital Velocity (km/s) 2 Radii	3 Radii	5 Radii
Mercury		2.08	1.70	[illegible]
Venus		5.17	4.22	[illegible]
Earth		5.58	4.55	[illegible]
Mars		2.51	2.05	[illegible]
Jupiter		30.01	24.50	[illegible]
Saturn		17.94	14.65	[illegible]
Uranus		11.11	9.07	[illegible]
Neptune		[illegible]	10.15	[illegible]
Pluto		[illegible]	0.86	[illegible]

Figure 2-2 *Orbital Velocity Table*

If your speed decreases below orbital velocity due to atmospheric friction, a deorbit burn, or—God forbid—a collision of some sort, your spacecraft will succumb to the pull of gravity and eventually plunge into the central object it is orbiting. If you increase your velocity beyond the momentum needed to balance the pull of gravity, your spacecraft will hurtle off into space. This is called achieving *escape velocity.*

As the *Space Simulator's Star-Pilot's Guide* points out, there are precise relationships that determine orbital velocity. Again, this is courtesy of Sir Isaac Newton. His law of universal gravitation shows how all objects in the universe, no matter how large or small, attract each other with a gravitational force that depends on their mass (weight) and the distance between them. More specifically, the attraction is directly proportional to the mass of the objects, and inversely proportional to the square of the distance between the objects (center to center).

PROFILE OF A SHUTTLE FLIGHT

Let's take a look at a space shot. In *Space Simulator,* you can launch your bird simply by using the Autopilot's handy Launch function. But in real life, gravity rears its ugly head, threatening always to pull your grand interstellar designs back into the dirt. What are the thrust requirements for shaking off the harness of this dusty planet?

We'll use a flight of the most advanced orbital vehicle to date, the U.S. space shuttle, to examine some of the complex dynamics of a space shot.

Prelaunch Prep

Start by imagining yourself a mission specialist, following the shuttle commander, pilot, and payload specialists through the gleaming white hatch of the shuttle *Discovery*. You are strapped securely into your assigned seat, in which you lie flat on your back, facing the sky. You listen to machinery all around you rumble and groan as the volatile liquid propellants boil and fume just a few feet away in the massive external fuel tank. You spend your last few Earthbound minutes checking communications, cabin pressure, and dozens of other critical systems, all the while aware of the inexorable march of seconds to launch.

In this particular voyage, *Discovery* is slated to lift off during a seven-minute "launch window" determined by certain mission-specific factors. These factors can include the type, weight, and destination of payloads (such as satellites) loaded on board for deployment; the position of the Earth relative to the Sun; and the desired conditions at your scheduled landing site. To verify the window, an extremely sophisticated system of computer-assisted gyroscopes known as the Inertial Measurement Unit (IMU) places *Discovery* in its exact position relative to the Sun and other celestial bodies.

This IMU displays an inertial truth that most of us ignore—a truth that adds a certain measure of complexity to any space shot with a particular destination. *Discovery*, which appears to be sitting motionless on Pad 39A at Cape

Figure 2-3 Space Simulator*'s shuttle sits poised on Pad 39A at Cape Canaveral, ready for launch.*

Canaveral, is in fact spinning eastward at about 1,000 MPH. The Earth, you may recall, rotates on its axis. This inertial whip is the reason why shuttle trajectories arc out east over the Atlantic range.

Liftoff

OK, so you're sitting on top of a rocket, a very big rocket. How big? Get this—when the tons of liquid hydrogen and its oxygen oxidizer finally mix, ignite, and

Figure 2-4 *A space shuttle launch is an awesome sight to behold. Five million pounds of thrust—enough power to light the Atlantic states—lift the orbiter into space in less than nine minutes.*

burst from the main engine nozzles, they produce a sudden upward thrust of more than 1 million pounds—"enough power at that moment," says astronaut Joe Allen in *Entering Space*, "to supply the state of New York." But that's just the beginning. When the twin solid rocket boosters roar to life about three seconds later, they kick out a mind-boggling 5.2 million pounds of thrust. Enough power, adds Allen, to light up the entire eastern seaboard.

Figure 2-5 *Less than a minute after lift-off, the massive rockets have kicked the shuttle up to 700 MPH. The atmosphere soon thins, the shuttle quickly accelerates to its orbital velocity of more than 17,000 MPH.*

Figure 2-6 *As the shuttle rises through the clouds, 3 g's of force will temporarily immobilize the astronauts, narrow their vision, sag their eyes, mouth, and jowls, triple their weight, and press them heavily into their seats.*

You're going up fast, very fast. How fast? *Discovery*, barely hovering above Florida's sea-level marshlands on a thundering plume of smoke, will glide into the vacuum of space in less than nine minutes.

So up you go. Seconds after launch, 3 g's of acceleration squeeze you into your seat and narrow your field of vision to dead ahead. Less than a minute after liftoff, *Discovery* is traveling more than 700 MPH, a speed it must not exceed until the atmosphere thins, or else the orbiter's wings and tail will be shredded. Computers throttle down the main engines a few seconds until the air pressure decreases. Once they throttle back to full power, however, the craft takes less than a minute to ramp up its speed to 3,000 MPH.

Into Orbit

You are now two minutes into the flight of *Discovery*.

At this point, the solid rocket boosters burn out, explode away from the main fuel tank, and parachute gently into the Atlantic for retrieval and reuse. Six-and-a-half minutes later the orbiter is 70 miles high, humming along faster than 17,000 MPH. Then comes MECO (main engine cutoff), after which the now-empty external tank is jettisoned.

A two-and-a-half-minute burn of *Discovery*'s OMS (orbital maneuvering system) engines boosts the shuttle's speed the additional 130 MPH necessary to reach orbital velocity of 17,590 MPH. The vehicle attains a looping, elliptical orbit. About 45 minutes later, a second OMS burn adjusts *Discovery*'s flight path to a steady circular orbit.

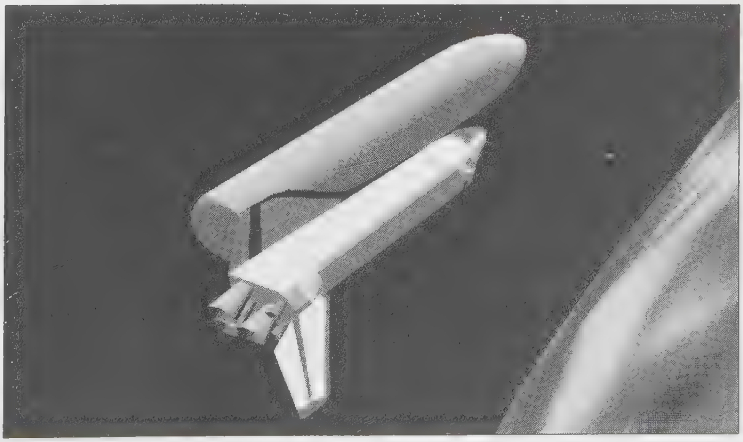


Figure 2-7 *Here is* Space Simulator*'s shuttle after shedding its twin solid rocket boosters. In another 6.5 minutes comes the critical moment known as MECO (main engine cut-off), after which that large, empty external fuel tank on the orbiter's belly will be jettisoned.*

Maneuvering in Space

Once in the silent vacuum of space, the 100-ton *Discovery* can assume any attitude (the direction it points) in relation to Earth; it makes no difference whether the wing, tail, nose, or belly of the craft is forward. Periodically, though, the pilot must alter the shuttle's attitude for a specific test.

For such minimaneuvering purposes, *Discovery* is powered by forty-four small multidirectional thrusters in the nose and tail. These minirockets fire in computer-controlled combinations to achieve everything from minor attitude adjustments to rapid rotations and "translation maneuvers," which are straight-line movements of the orbiter in any direction.

For larger, more significant maneuvers—the final thrust to orbital velocity described earlier, or major orbital path changes, or the final burn to slow the craft for reentry—*Discovery* is powered by the two large OMS engines on the rear fuselage.

HUMAN PHYSIOLOGY IN SPACE

It's hard to believe that less than forty years ago, most experts thought human beings could not possibly survive spaceflight. Surely the tremendous acceleration needed to reach escape velocity would tear a human body apart. Zero gravity would cause lung failure, or disrupt pulmonary processes to the point where blood would stop flowing.

Today, obviously, we know better. Many men and women have lived and even thrived in the weightless environment of space. But there's no doubt that an unprotected human body would undergo some pretty chilling experiences not long after liftoff.

For example: At an altitude of about 63,000 feet, the drop in air pressure drives the boiling point of water down to around 98 to 99 degrees Fahrenheit. Think about this for a minute. The average human body temperature is 98.6 degrees Fahrenheit. A star-pilot traveling without benefit of a pressure suit would suddenly find his blood and other bodily fluids beginning to bubble and boil, simmered to steam by the heat engine of his own body.

If you think that's bad, imagine a sudden unpressurized exposure to near-space or vacuum conditions. The result of such an exposure is called *explosive decompression*, and it's just as horrific and disgusting as it sounds.

There are other, slightly less dramatic effects of the pressure loss that comes with increased altitude. The percentage of oxygen saturation in the

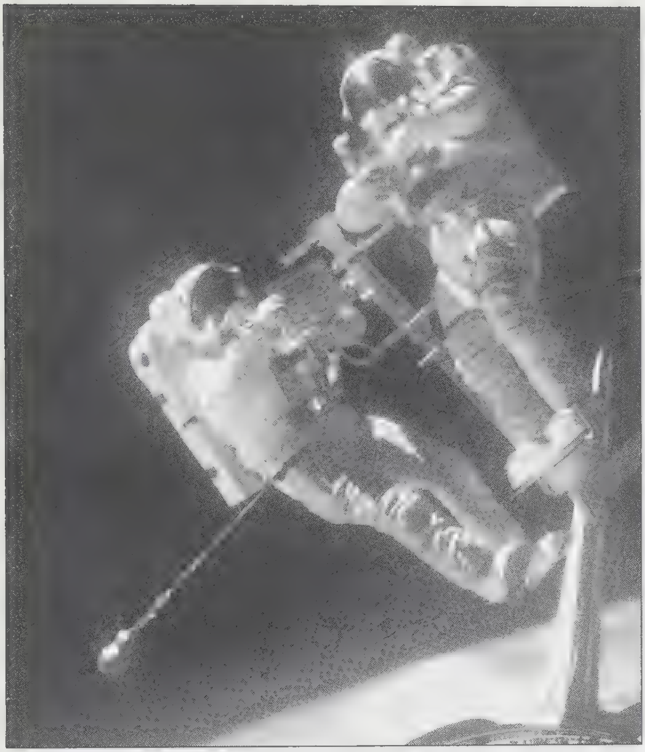


Figure 2-8 Astronauts Dale Gardner (with sign) and Joe Allen need more than just oxygen during their EVA. It wouldn't be quite so much fun hauling satellites into Discovery's *cargo bay if those suits weren't pressurized. Without air pressure, fluids in your body would burst into steam in an explosive decompression.*

blood drops as well. At sea level, your blood is 95 percent saturated with oxygen. At just 20,000 feet, however, the saturation level drops below 70 percent. This is called *hypoxia*, and the physiological reactions are not good—dimming of vision, tremor of hands, fogging of thoughts, loss of memory, major errors in judgment, to name a few.

Unfortunately, just pumping oxygen into your face mask won't raise your blood's oxygen saturation levels if you happen to be going up at the time without the benefit of a pressurized cabin or suit. As altitude increases, the drop in air pressure causes water vapor from your body fluids to accumulate in the alveolar sacs of the lungs, crowding out oxygen. At 50,000 feet, this effect becomes total. In effect, your body drowns itself.

Say, did I mention the effect of g-forces yet? The measure g is used to express the force of gravity based on its pull at the surface of the Earth. Accelerating produces a positive increase in g-forces; deceleration produces negative g-forces. The positive-g tolerance of the human body varies with the individual, but the following lists the average physiological reactions to increasing g-forces.

Note: The figures below apply to a steady head-to-foot application of the listed g-force to a person in a sitting position.

2 g's	Feeling of being pressed down by a strong, sustained force.
3 g's	Arm and leg movement is difficult. Corners of eyes, mouth, jowls sag significantly.
3.5 to 5 g's	"Grayout" occurs—that is, eyesight begins to dim.
4 to 5.5 g's	Total vision blackout occurs. The subject is still fully conscious, but cannot see. Reason: Impaired circulation reduces the blood (with its oxygen) flow to the head. Each eye's retina is extremely sensitive to lack of oxygen, more so than any other part of the body.
4.5 to 6 g's	If maintained for three to five seconds, loss of consciousness occurs. If maintained for some minutes, this g-force will result in death due to circulation failure. Reason: Between the heart and the brain is a column of arterial blood roughly 12 inches high. At about 5 g's, the downward pull of gravity equals the upward push of blood pressure. Blood cannot reach the brain, nor can blood pooled in the lower extremities return to the heart. If the g-force continues, the heart pumps to no avail.

Have I soured your desire to be an astronaut yet? I hope not. Because the experiences of both the Soviet and American space programs show that proper preparation, eating, and exercise regimens can make even extended spaceflight a fairly pleasant, even exhilarating experience.

Barring some malfunction in major life-support systems, the biggest problem of living in space is the free ride that zero gravity gives our physiology. On earth, we fight gravity every moment of the day. In space, muscles have nothing to resist, so they atrophy. Bones decalcify and deteriorate. Senses become so disoriented that many astronauts get spacesick. Dehydration is a major problem, and the circulatory system suffers a serious depletion of red blood cells, electrolytes, and hormones. There can be problems with depth perception and eyestrain, even short-term hallucinations. Faces swell up; sinuses congest, causing headaches. Overall, you can feel a flulike lethargy.

But if you read the story of the Skylab missions in Chapter 1, you already know that many of these physiological effects can be countered. As one NASA pamphlet on "Space Flight Research" points out, postflight examinations of the Skylab crews yielded some surprising and heartening results.

> Upon return to Earth, the crew of the second manned Skylab mission (59 days) readapted more quickly than did those on the first mission even though they had been in space over twice as long. [The crew of the first Skylab mission spent 28 days in space.] . . . On the basis of this experience, tentative approval was granted to extend the third manned mission to 84 days. It is significant that the members of the 84-day mission returned in even better physical condition than did the crews of the previous missions. Obviously, travel in space for prolonged periods is feasible.

The medical evidence from that last Skylab mission showed that the human body, while initially disoriented, eventually stabilizes and adapts quite

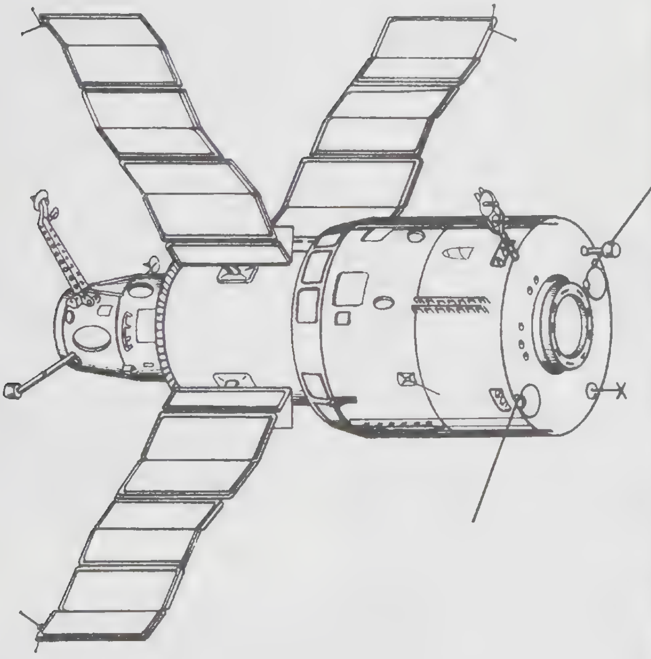


Figure 2-9 *In 1979, Cosmonaut Valeri Ryumin spent 175 days in space aboard* Salyut 6 *(sketch shown above), returning to Earth with significantly decalcified bones. However, the condition reversed itself in a matter of days, proving that human physiology is quite adaptable to space living.*

well to weightlessness, given the right environment and physical training.

Russian test results have been encouraging as well. When cosmonaut Valery Ryumin returned from his six-month-long *Salyut 6* mission in 1979, his bones had decalcified considerably—that is, a lot of calcium had drained from his bones into his bloodstream. But oddly enough, Ryumin seemed perfectly fine. In fact, he was walking in one day, jogging in three. He had suffered no major debilitating effects. Many scientists now believe that decalcification does not really harm people in the long run, because calcium loss is quickly reversible.

HUMAN PSYCHOLOGY IN SPACE

Nobody really knows how any particular human being's mind will react to a space environment. People, after all, can be extremely unpredictable when it comes to matters of individual temperament. But there can be no doubt that extended space travel places unique strains on the human psychological state as well as the human body.

Imagine: No up, no down. Nothing stays in place. The continual need to Velcro or clip every movable thing in place means that even the most menial

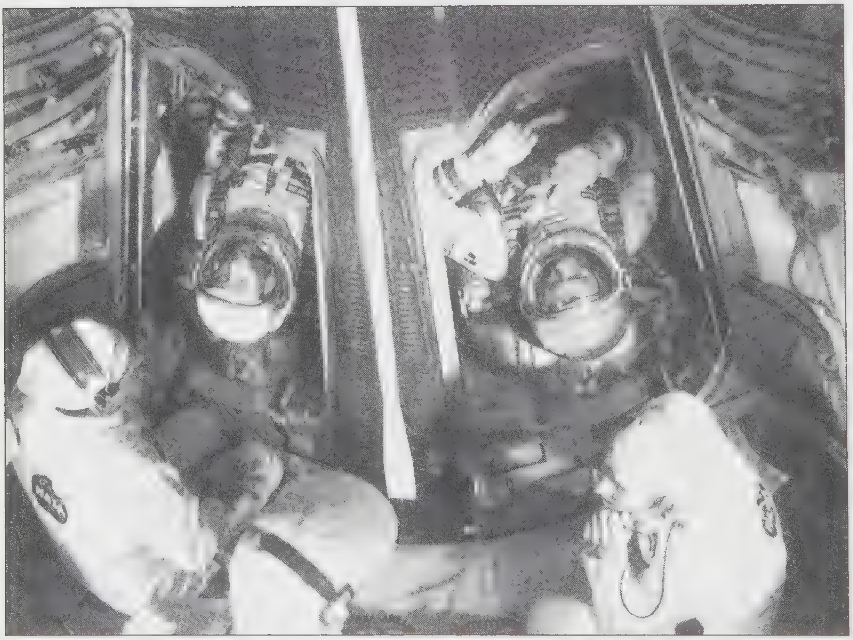


Figure 2-10 *Astronauts Gene Cernan and Thomas Stafford are literally packed into their tiny* Gemini 9 *capsule by NASA technicians.*

tasks must be carefully performed. Indeed, minor mishaps are common for zero-g rookies in the first days of every spaceflight. In his book, *Entering Space*, Joe Allen says, "Watching inexperienced crews trying out their 'space legs' is like watching a small skating rink crowded with adults who are on ice-skates for the first time."

Cosmonaut Yuri Romanenko spent 326 days alone aboard the Soviet space station *Mir*. By the end of his eleven-month flight, he was down to only two hours of productive work a day, and had begun to bicker regularly with Soviet

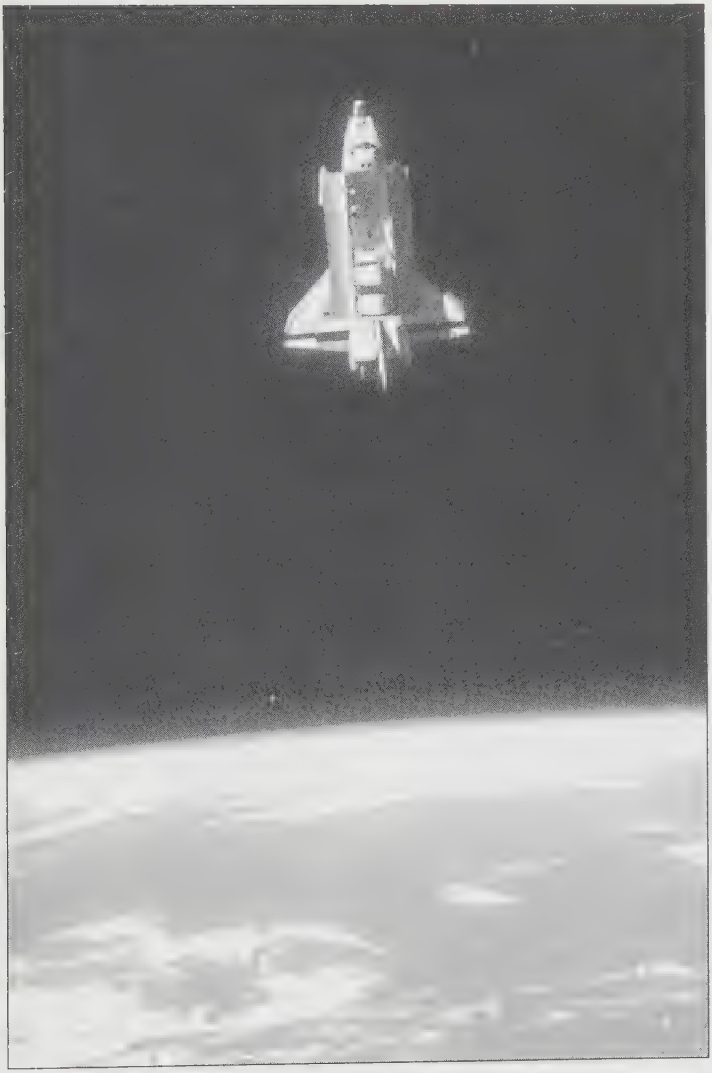


Figure 2-11
The orbiter can travel through space in any attitude—forward, backward, up, down—since there is no air to create aerodynamic drag. It also leaves its cargo bay doors open during most of its mission to help dissipate the tremendous build-up of solar heat.

mission controllers. Of course, solitary space travel is much different from the group conditions that would undoubtedly accompany interstellar flight. Respect, cooperation, and above all, a sense of humor seem to be key components of a good spaceflight team.

LIVING, WORKING, AND PLAYING IN ZERO GRAVITY

In 1984, cosmonaut Oleg Yur'yevich Atkov spent eight months aboard the *Salyut 7* orbiting station. Upon his return, he reported: "Our adjustment to zero-gravity was surprisingly easy and fast." He credited special preflight con-

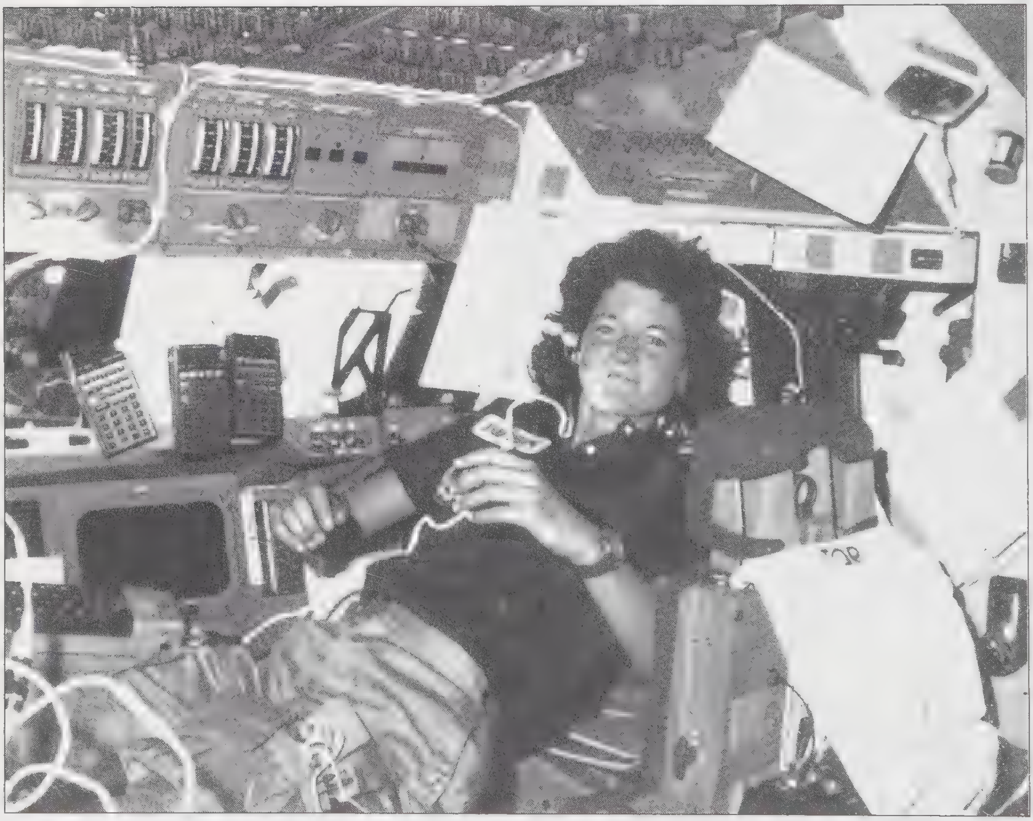


Figure 2-12 *Dr. Sally K. Ride floats amongst papers, clipboards, calculators, and food containers aboard the* Challenger. *During this STS-7 mission, Dr. Ride became the first American woman in space.*

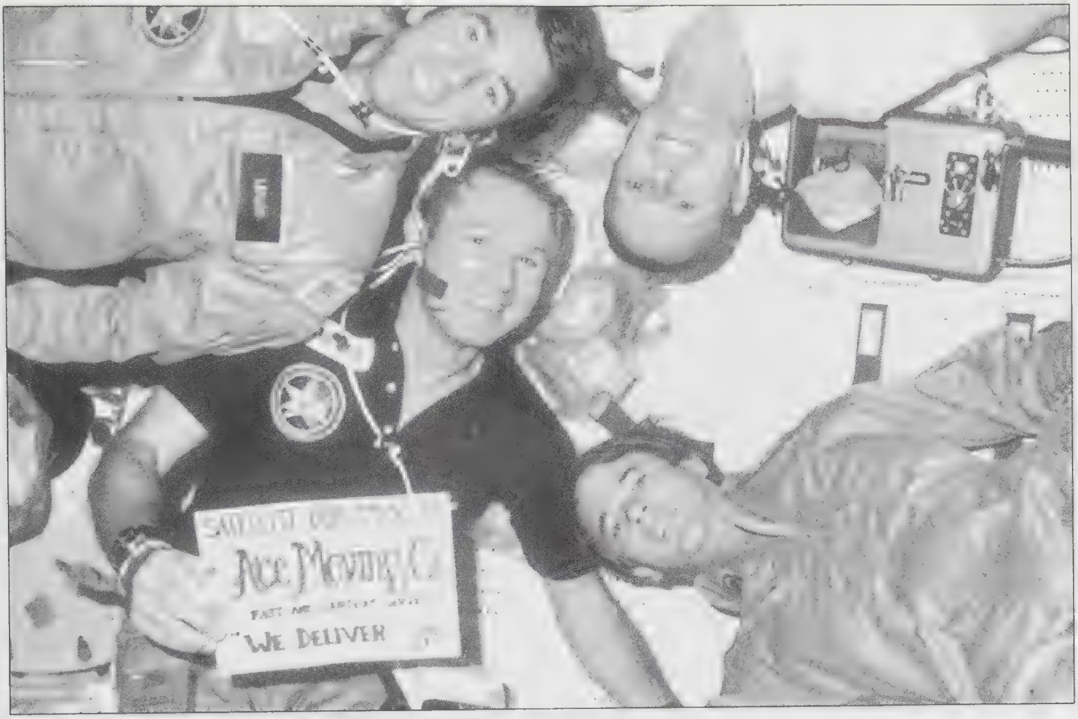


Figure 2-13 *A zero-gravity environment is simultaneously disorienting and fun for newcomers. Here, the crew of STS-5 come up with a new angle for a group photo.*

ditioning sessions. By the second day, the *Salyut* crew had adjusted quite comfortably to the conditions of weightlessness.

Zero gravity, in fact, can be exhilarating, according to those who've experienced it. Joe Allen describes it in *Entering Space* as "a strange and sublime experience that is at once bizarre and immensely enjoyable." Astronauts have found it endlessly intriguing, transforming routine tasks and movements into interesting thought-puzzles. Just as an ever-challenging series of new mazes causes 10 percent brain growth in laboratory rats, so can the constant rethinking of everyday situations stimulate the human brain.

The physical sensation of weightlessness, after some initial adjustment, can be quite pleasurable as well. Sleeping, for one thing, is a joy; zero g is the perfect mattress. And the general freedom to kick off from any surface into a zooming Superman glide (maybe adding a flip or two) across the cabin or lab is so liberating that it is sometimes hard to resist. "It appeals to the child in you," admits one astronaut. Another notes: “It’s kind of like playing in a waterless swimming pool.”

Personal hygiene in a zero-gravity environment is a complicated endeavor. Since water does not fall “down” into a drain, it must be contained within waterproof stalls for showering (in some vehicles), or special enclosed-dome devices for washing hands. Once used, water must be removed by air suction. Toilets are equipped with seat belts, handgrips, and foot restraints, with vacuum airflow to pull waste into an outer storage tank. Even electric shaving requires a special nozzle to suck away bits of whisker. While floating whisker bits may seem inherently comical, they could in fact be deadly if they drifted into vital life-support equipment.

On the other hand, eating is much easier than researchers once feared. Chewing and swallowing are barely affected by gravity, and food holds together well, so no special utensils are necessary. In fact, since food has no weight in space either, its own surface tension keeps it within its containers. Liquids, though, behave in a most unusual fashion. Orange drink squeezed from a container will sit on the tip of the straw like a quivering orange bubble. Again, Joe Allen describes an effect that “borders on slapstick comedy”:

> If disturbed . . . [the floating globe of liquid] shivers, vibrates, and oscillates . . . Once it touches any relatively flat surface, it changes its shape instantly from a sphere to a perfect hemisphere . . . and it stays attached for hours or days unless mopped up by a towel or, better yet, chased down by a thirsty astronaut.
>
> *(Entering Space: An Astronaut’s Odyssey)*

Work, of course, consumes the bulk of each day during a space shuttle mission. In the early years of spaceflight, work focused on the experience of spaceflight itself. Today’s space tasks are more commercial in nature. Payload and mission specialists deploy or pick up and repair satellites, or conduct any number of experiments commissioned by companies from around the world. The “right stuff” jet jockey astronauts of a previous era have been replaced by skilled workers—scientists, technicians, and engineers.

EVA

Since cosmonaut Alexei Leonov and astronaut Ed White drifted from their respective space capsules in the spring of 1965, dozens of men and women

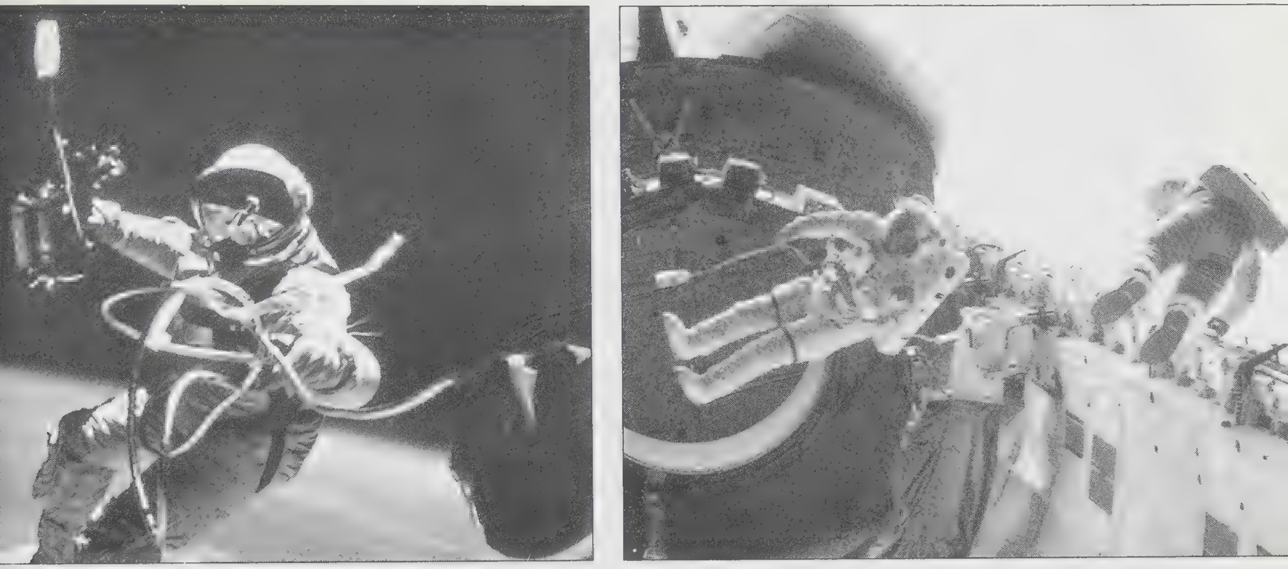


Figure 2-14 Left: *Ed White's spacewalk in 1965 was America's first EVA.* Right: *Today, astronauts perform EVAs with workmanlike regularity and purpose. Shuttle astronauts have spacewalked to repair everything from balky satellites to the Hubble Space Telescope.*

have conducted spacewalks, known as EVAs (extra-vehicular activity). In the early days of EVA, spacewalkers clung to rungs and depended on a coil of rope to keep them tethered to their spacecraft. Today, astronauts use a truly space-age device called an MMU (manned maneuvering unit). Perhaps you've already checked out the MMU in *Space Simulator*.

First tested by astronaut Bruce McCandless in 1984, an MMU is basically a rocket backpack. Its engine directs tiny, controlled burns out of twenty-four mini-nozzles that work like the shuttle's own multidirectional thrusters. The controls are quite precise, giving the astronaut unlimited mobility within a certain range of the spacecraft.

REENTRY . . . OR NOT

Your mission is now complete.

At this point, you could try to break free of Earth's gravity and cruise off into space. This would require acceleration to Earth's escape velocity, which from

Figure 2-15 Top: *In 1984, astronaut Bruce McCandless space-tested the MMU (manned maneuvering unit) for the first time during mission 41-B of the shuttle* Challenger. Right: *The MMU in* Space Simulator *lets you make your own EVA.*

your current orbit would be about 24,000 MPH. (From the surface, escape velocity would be 25,020 MPH. Obviously, escape velocity decreases the farther you get from the central object and its gravity.)

Unfortunately, *Discovery*'s engines are incapable of accelerating to this velocity. The shuttle was designed to be an orbiter, not an interstellar spacecraft. Should you happen to be flying another member of the *Space Simulator* fleet later, here is a table of escape velocities for the Solar System:

Planet	**Escape Velocity, Surface (MPH)**
Moon	5,328
Mercury	9,612
Venus	23,184
Earth	25,020
Mars	11,268
Jupiter	134,748
Saturn	72,180
Uranus	50,328
Neptune	53,460
Pluto	2,707
Sun	1,381,608
Ceres (asteroid)	1410

For now, let's go back home.

For *Discovery*'s return to Earth, you need to wear a g-suit, which is an inflatable, trouserlike undergarment designed to squeeze the lower body. This squeeze prevents the pooling of blood caused by the g-forces during reentry, which in turn prevents the tunnel vision or blackout that can result. Once properly suited, the commander and pilot are ready to position the shuttle for a retrograde adjustment to orbit—tail first, the two OMS engines facing in the direction of travel, ready to fire to reduce *Discovery*'s velocity.

Halfway around the world from the scheduled landing site in California's Mojave Desert, the engines ignite and burn for about three minutes. This slows *Discovery* by a mere 200 MPH, but it is enough to drop the craft below orbital velocity, allowing gravity and then the upper atmosphere to provide the brakes needed for the deorbit maneuver. When the burn ends, the commander and pilot turn the shuttle 180 degrees to a *prograde* orientation (nose facing the direction of travel), then pitch the nose up 40 degrees. This lets *Discovery* hit the atmosphere belly-first so that the protective tiles on its underside can shield the orbiter from the white heat produced by friction with the air.

The orbiter's altitude now drops quickly from 160 miles to about 75 miles, where it begins to visibly collide with air, and the friction of this collision heats the insulated leading edges of *Discovery* to a quite toasty 2,500 degrees! Former shuttle astronaut Joe Allen describes the flaming passage back home:

> The crew members, seated only a few feet from the blazing exterior, feel no increase at all in the cabin's temperature. They are riding safely inside a flying furnace, surrounded by the intense heat that completely destroys the vast majority of the thousands of meteors that encounter the atmosphere each year. But the shuttle orbiter is a meteorite that survives this conflagration virtually undamaged.
>
> *(Entering Space: An Astronaut's Odyssey)*

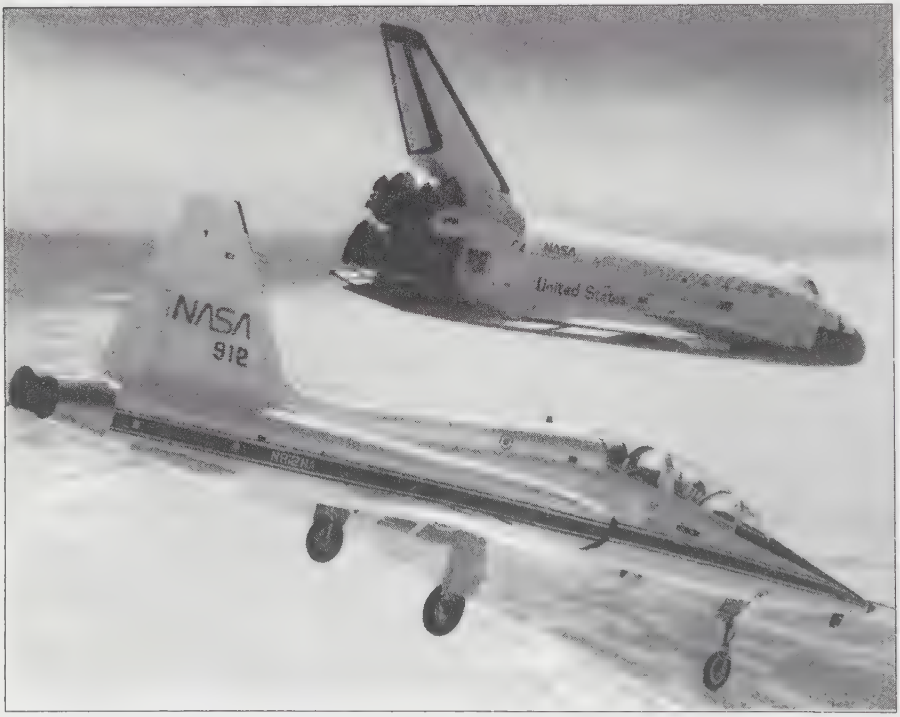


Figure 2-16 *A NASA artist depicts a supersonic T-38 chase craft escorting the shuttle* Columbia *over the California's Tehachapi Mountains en route to its landing at Edwards Air Force Base.*

The force of deceleration caused by the friction tops out at less than 2 g's, but after the weightlessness of space, it feels quite profound. As the atmosphere thickens with descent, the light hiss of air passing over *Discovery*'s aerodynamic surfaces slowly builds to a powerful roar. The unpowered craft, now essentially a 100-ton glider, is flown by the pilot in a series of steeply banked S-shaped turns to dissipate speed.

As it penetrates into denser air, the shuttle becomes an airplane, now that its wings and tail have something to bite into. After slowing down to a manageable 200 MPH, *Discovery* finally lumbers to a landing at Edwards Air Force Base in California.

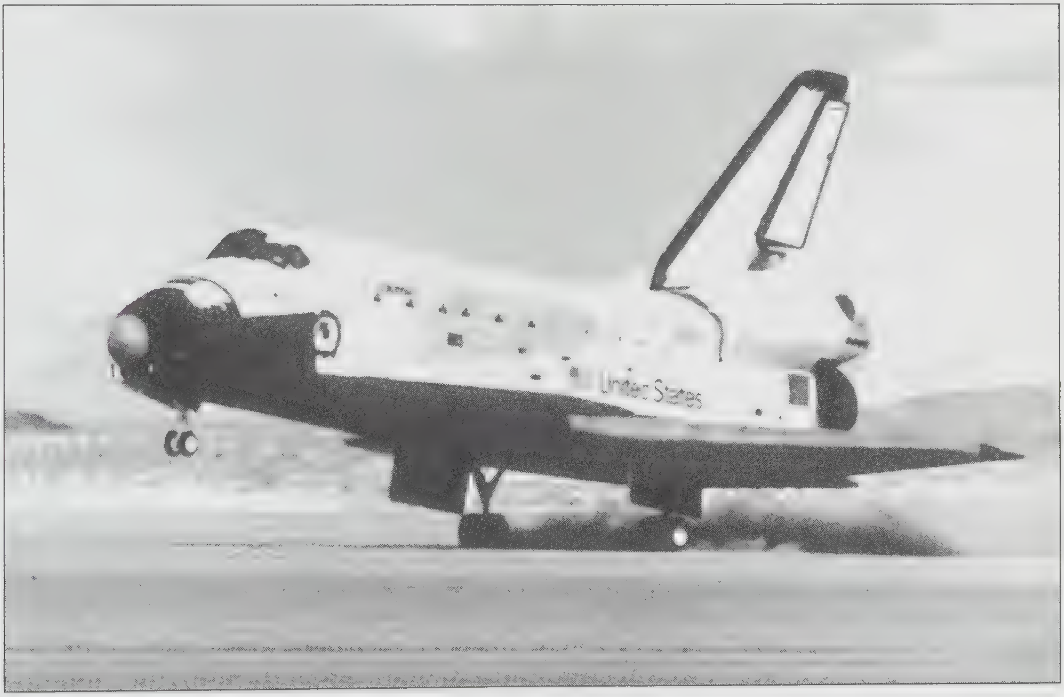


Figure 2-17 Columbia *touches down after its successful maiden flight in April of 1981.*

Chapter 3

The Future of Spaceflight: Fact and Fantasy

Any sufficiently advanced technology is indistinguishable from magic.

—Arthur C. Clarke's "Third Law"

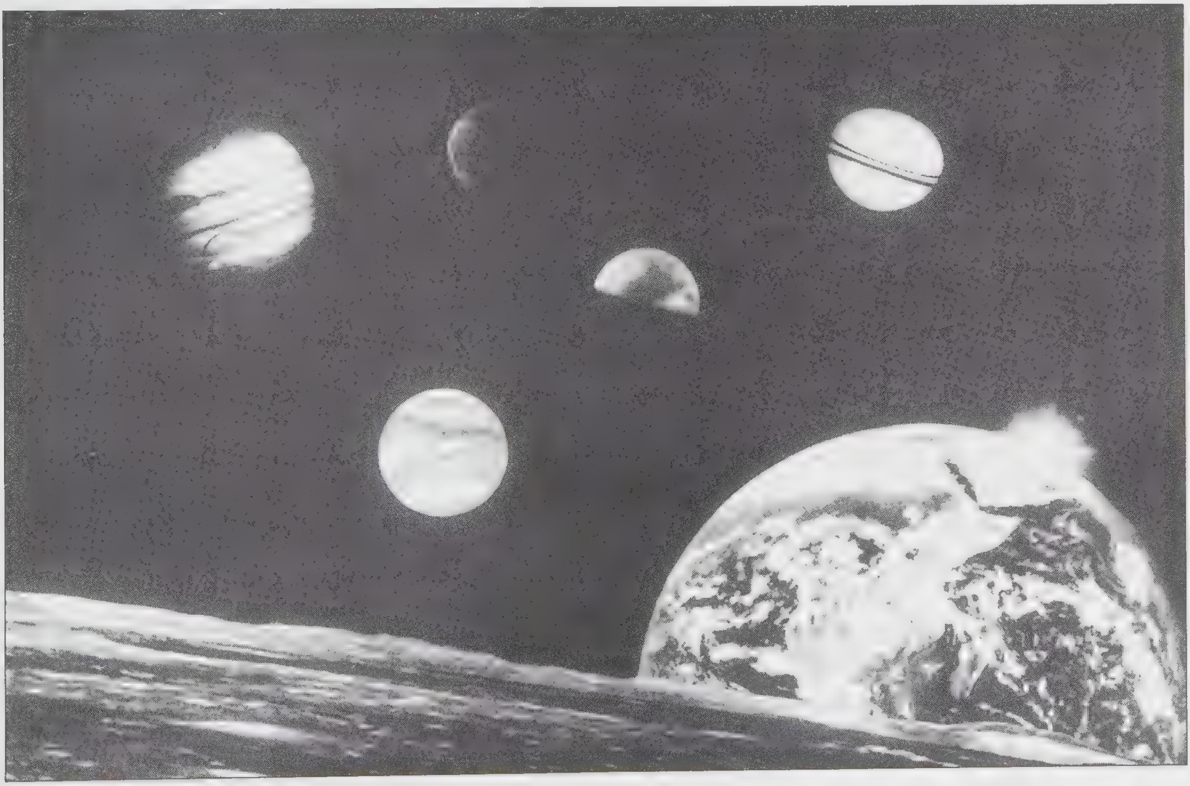
Even if intelligent life is common in the universe, it should come as no surprise that we have not been visited. Perhaps their appropriations committees are just as reluctant as ours to finance projects that would take thousands of years or that require thousands of years of their planet's energy needs.

—Bernard Oliver

Imagine the following: You've been called into a top-secret briefing by directors of the SETI (Search for Extra-Terrestrial Intelligence) Project, NASA's ambitious ten-year search for radio signals indicating intelligent life in deep space. A pale SETI scientist is describing the detection of a set of intermittent microwave pulses—a nonrandom, repeating signal with a duration of forty minutes.

He calls it the ultimate modem.

Figure 3-1 *Mankind's expeditions to the planets of the Solar System have revealed no evidence of life. But what lies beyond?*



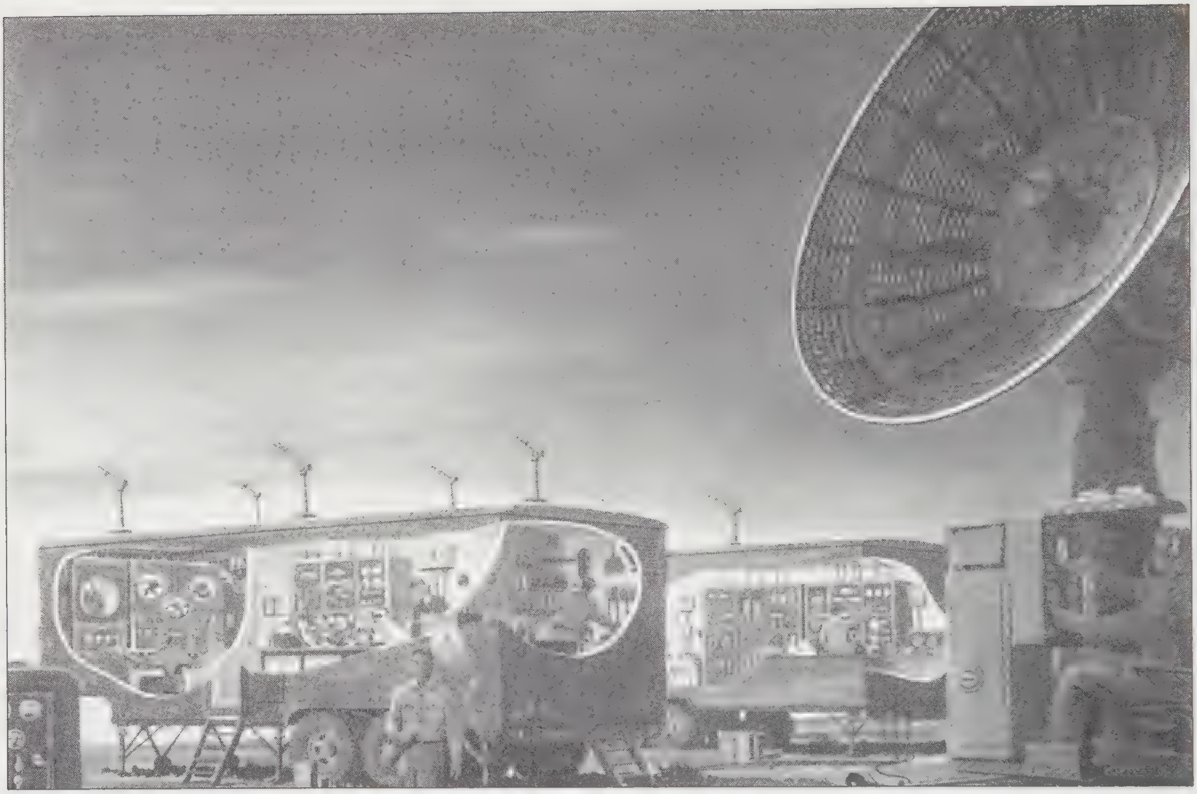


Figure 3-2 *The SETI Project is NASA's current attempt to seek signs of intelligent life in outer space. Radiotelescope dish antennae scan the sky on hundreds of thousands of radio channels, looking for a signal that might be sent from another civilization.*

On a large star chart, he pinpoints the location of the signal's source: a system in the Andromeda galaxy, more than 2.2 million light-years away.

He goes on to describe how the signal was immediately downloaded into NASA supercomputers. After months of painstaking analysis, SETI scientists managed the decryption of what turns out to be an astounding transmission. The signal, apparently, was somehow hyperpropelled far beyond the speed of light. It was received in real time.

How do we know?

The senders were very precise, says the scientist, about our recent geological past.

How recent?

"They want to know if the L.A. earthquake affected our instruments at Cal Tech."

The transmission also contains:

- Astronomical coordinates pinpointing the location of a fully operational starship locked in stationary orbit around Callisto, a moon of Jupiter.
- Full engineering specifications for the starship. Christened *Callisto* by NASA, it features three powerful gravity drives which create an artificial gravity well just in front of the craft, pulling it forward. *Callisto*, it appears, can accelerate with ease to near-relativistic velocities.
- Software code for a complex navigational computer geared for *Callisto*'s operations.
- An invitation.

A fun fantasy, isn't it? And it's one that *Space Simulator* lets you indulge fully. But just how fantastical is it? Could intelligent life—or any life-form, for that matter—exist elsewhere in the cosmos?

IS ANYONE OUT THERE?

Science has long debated whether or not intelligent life could evolve elsewhere in the universe. Modern research traces life's origins to titanic supernova explosions that continually spew out "stardust," which then gathers into vast protoplanetary nebulae. This dust is made up of biogenic elements and compounds that have somehow fused and evolved into intelligent life on Earth. Is this phenomenon unique to our planet?

Two very recent discoveries support the concept that life could well occur elsewhere in the universe. Researchers from the University of Illinois, using radio telescopes, detected the presence of a common amino acid molecule in the large gas clouds of Sagittarius B2, an active star-forming region near the center of the Milky Way galaxy. Amino acids are produced by organisms that can reproduce themselves, such as living cells.

The amino acid found in Sagittarius B2—glycine—plays a pivotal role in the development of many types of proteins. This remarkable find proves that a critical building block of life exists in deep space. Before this discovery, no other

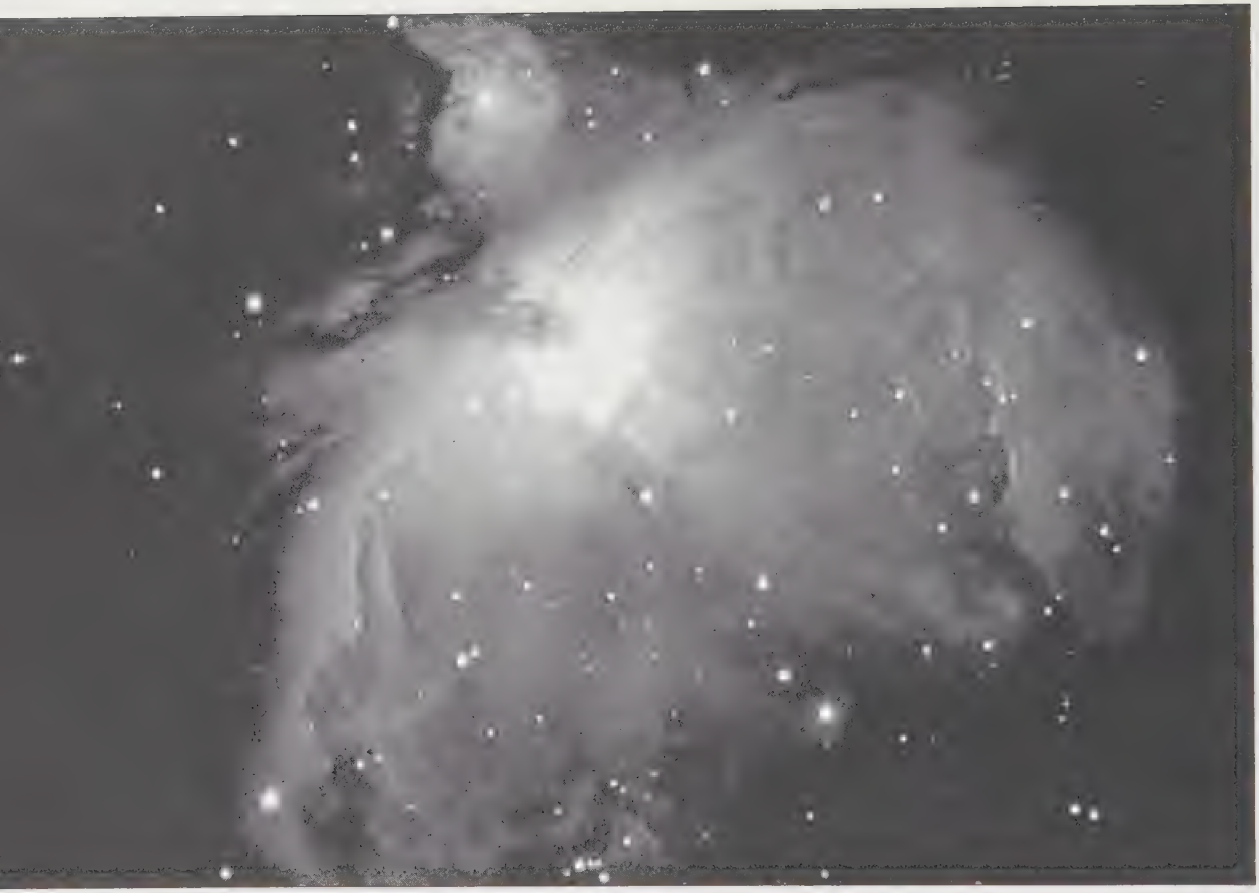


Figure 3-3 *The origins of life can be traced to fertile protoplanetary breeding grounds such as the Great Orion Nebula, shown here. This star-forming region is thought to be awash in "stardust" that contains the basic molecules of life.*

basic molecule of life had been listed among the more than 150 organic molecules detected in deep space.

But there's more news. Astronomers from the University of Maryland recently made another startling discovery. Water, the substance so vital to life on Earth, was detected in abundance in Markarian 1, a galaxy more than 200 million light-years away. This suggests that water molecules may be more widely distributed throughout the universe than previously believed.

These indications bode well for the exciting possibility of other life-forms living "out there." But before considering deep-space travel and distant alien encounters, let's take another peek around the neighborhood first.

Figure 3-4 *Water, the elixir of life, has been detected in abundance in a distant spiral galaxy known as Markarian 1, more than 200 million light-years away. If water molecules are this widely distributed, perhaps life-forming conditions are widespread as well.*

MARS MISSION

Mars has always fascinated stargazers and dreamers. The nineteenth century astronomer Percival Lowell spent his entire adult life devoted to the study of Mars and its famous "canals" which, it turns out, do not actually exist. His obsession spilled into books and lectures that spurred the imagination of the public and moved writers such as H. G. Wells (*War of the Worlds*) to speculate on the prospect of intelligent life on Mars.

Of course we know now that Mars is actually a rocky red wasteland. Similar

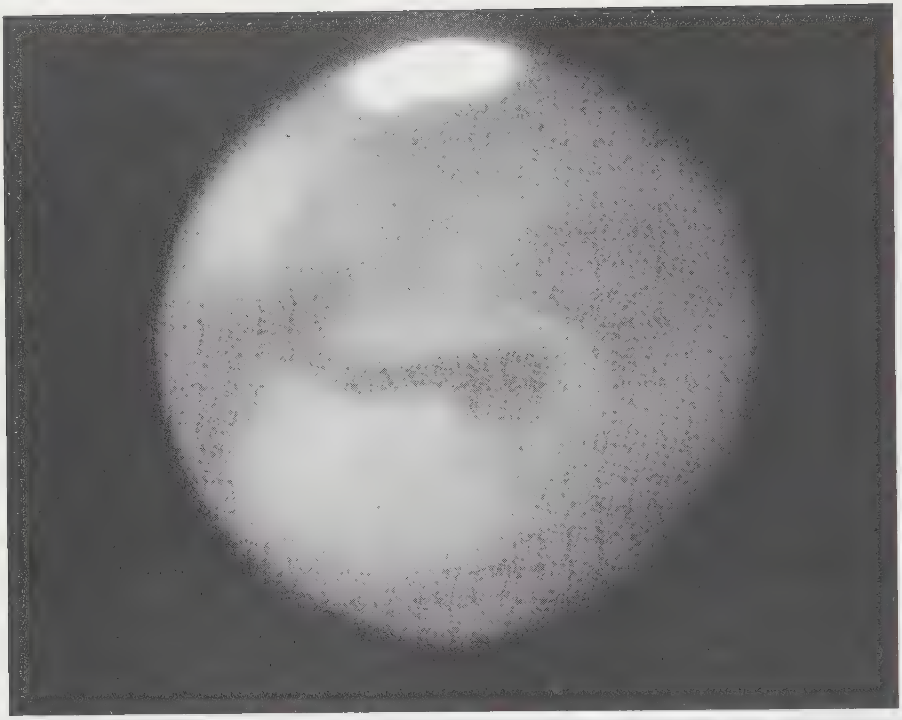


Figure 3-5
Before Mariner *and* Voyager *missions, our early speculation on extraterrestrial life focused on Mars. Is it any wonder? This hazy telescope view of Mars only seems to enhance its mystery.*

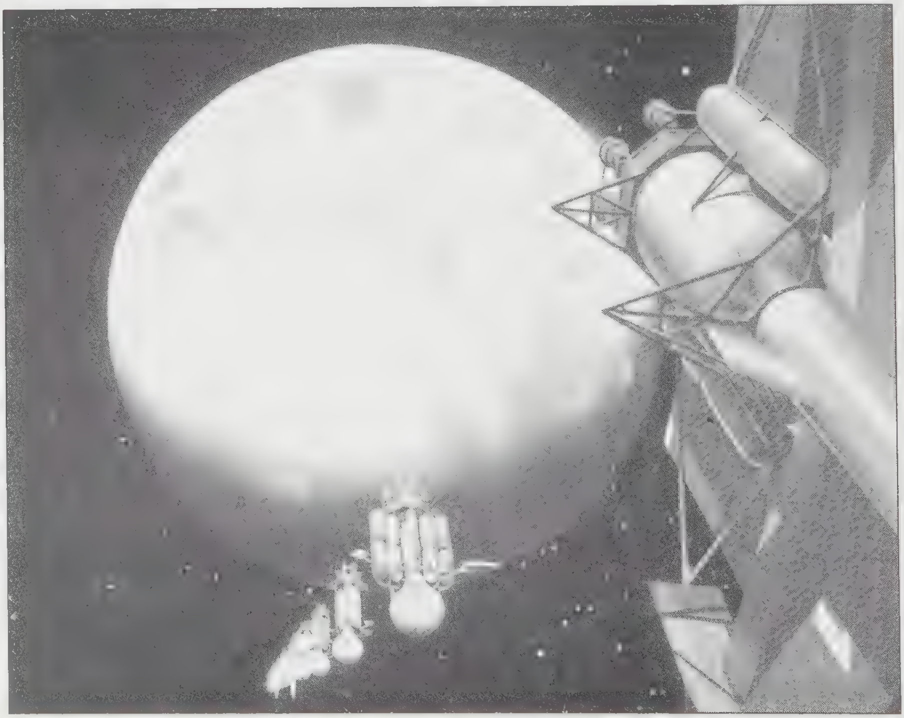


Figure 3-6
In the early days of the U. S. space program, eminent rocket scientist Wernher von Braun developed scenarios for a manned Mars mission. Here's an artist's depiction of von Braun's spaceship flotilla to Mars.

to Earth in some ways—size, distance from the Sun, twenty-four-hour days, four seasons, and an atmosphere containing common Earth elements—Mars nonetheless is an extremely forbidding habitat. First of all, Mars is a frigidly cold desert world. Its atmosphere is about a hundred times thinner than Earth's. As a result, deadly cosmic rays would destroy any unprotected life-forms imported from Earth. (Our own thick atmosphere protects us from this radioactive bombardment.) Furious dust storms regularly sweep the surface as well.

This naturally raises the question: Why go to such a godawful place? Especially when current cost estimates hover in the $90 billion range? One reason: Despite the inhospitable nature of the Martian environment, there is substantial evidence to suggest that it was not always so.

Indeed, *Viking* photographs of the planet's surface reveal ancient riverbeds, towering polar ice caps, and geological structures consistent with sea formation. The Viking data also indicates significant amounts of water trapped beneath the Martian surface. If Mars was once wet and warm, as such evidence suggests, then the chemical soup of its seas may have spawned life-forms. The presence of Martian fossils—or even a primitive, microbe-level biology—would be a scientific discovery of unprecedented proportions; one that would dramatically increase the likelihood that life not only exists, but exists in abundance elsewhere in the universe.

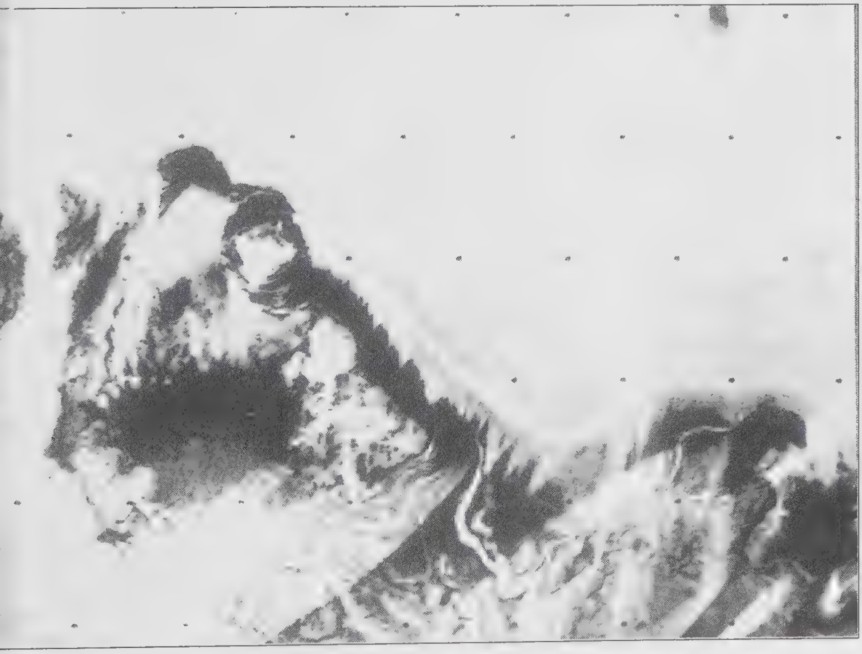
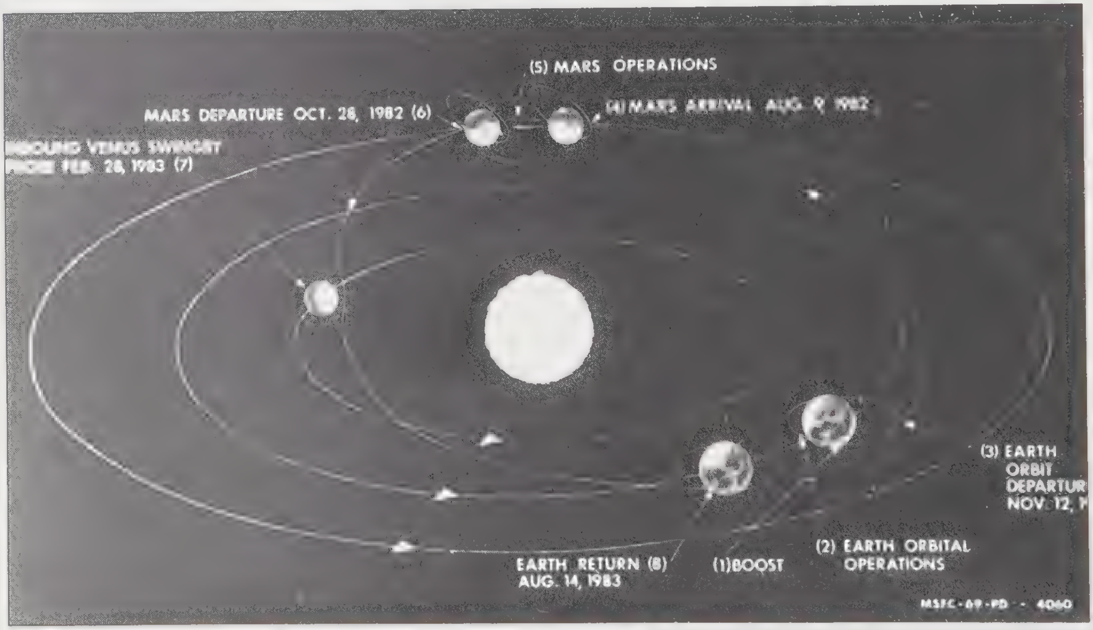


Figure 3-7
Towering ice cliffs in the Martian polar region, along with other land formation activity, suggests the possibility that Mars was once wet and warmer . . . and perhaps teeming with some sort biology, if only in microbe forms.

1981 Mars Landing Mission Profile

This artist's concept depicts an early Mars mission profile proposed by NASA. While the dates were clearly wishful thinking (1981–1983), the elements of the plan are still central to most NASA projections for such a mission.

Sections of the spacecraft would be boosted (1) into Earth orbit for assembly and other preparatory activies (2). The planetary vehicle would leave (3), aided by two reusable "shuttle" stages, then arrive at Mars (4) approximately nine months later. It would orbit Mars for 80 days, executing various surface landing missions (5) before departing (6). Four months later, the expedition would swing by Venus (7), then return to Earth (8), completing a 21-month round trip.


(5) MARS OPERATIONS
MARS DEPARTURE OCT. 28, 1982 (6)
(4) MARS ARRIVAL AUG. 9 1982
BOUND VENUS SWINGBY
FEB. 28, 1983 (7)
(3) EARTH ORBIT DEPARTUR
NOV. 12,
EARTH RETURN (8)
AUG. 14, 1983
(1)BOOST
(2) EARTH ORBITAL OPERATIONS
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Speaking about Mars at Rockefeller University in 1985, Nobel laureate Joshua Lederberg stated that "the possibility of life (and certainly of fossil life) should not be written off. . . . We have as yet sampled only two very similar habitats [with our *Viking* landers]; there remain many enigmas of fossil drainage patterns, as well as the unexplored polar cap zones."

What sort of effort would it require to get to the red planet? Sure, we went to the Moon. But that was a mere 240,000-mile jaunt. Compare that to the 45 million miles a Mars mission would have to travel. Joint efforts with the space programs of other nations, particularly our former rivals in Russia, would not only spread the cost around, but also set a precedent of international cooperation in space. But it would still be expensive.

What about the technology requirements? Carl Sagan is quoted in *Space: The Next 25 Years*, "It can be done. It is technologically feasible. It requires no major breakthroughs." Current NASA speculation focuses on the launch of two spacecraft—first, an uncrewed cargo hauler full of equipment, rover vehicles, and fuel for the return trip; then a separate craft with a crew of astronauts.

A spacecraft fueled by current chemical propellants would take at least a year, and probably longer, to make the round-trip to Mars. Could human beings endure such a long stay in space? Evidence from extensive studies in space longevity on the Russian *Mir* space station suggests that people can survive quite well, given the proper training, diet, and exercise regimen.

Once there, a landing party would assemble a prefabricated structure to house equipment, vehicles, and crew. They would then collect samples, conduct studies and experiments, map the region, and so on. After spending about a month planetside, the Mars team would load essential samples and other materials into an ascent vehicle and rocket up to the waiting command module in a manner similar to the Apollo moon expeditions.

Establishment of a permanent "Mars Base Marineris" like the one in *Space Simulator* is not very likely to happen within the next twenty-five years or so. Although the appropriate technology already lies in our hands today, cost and other research priorities will undoubtedly push any Mars Base endeavor well into the future.

Figure 3-8 *The technology exists today for construction of an outpost such as Mars Base Marineris in* Space Simulator. *Unfortunately, the funding does not.*

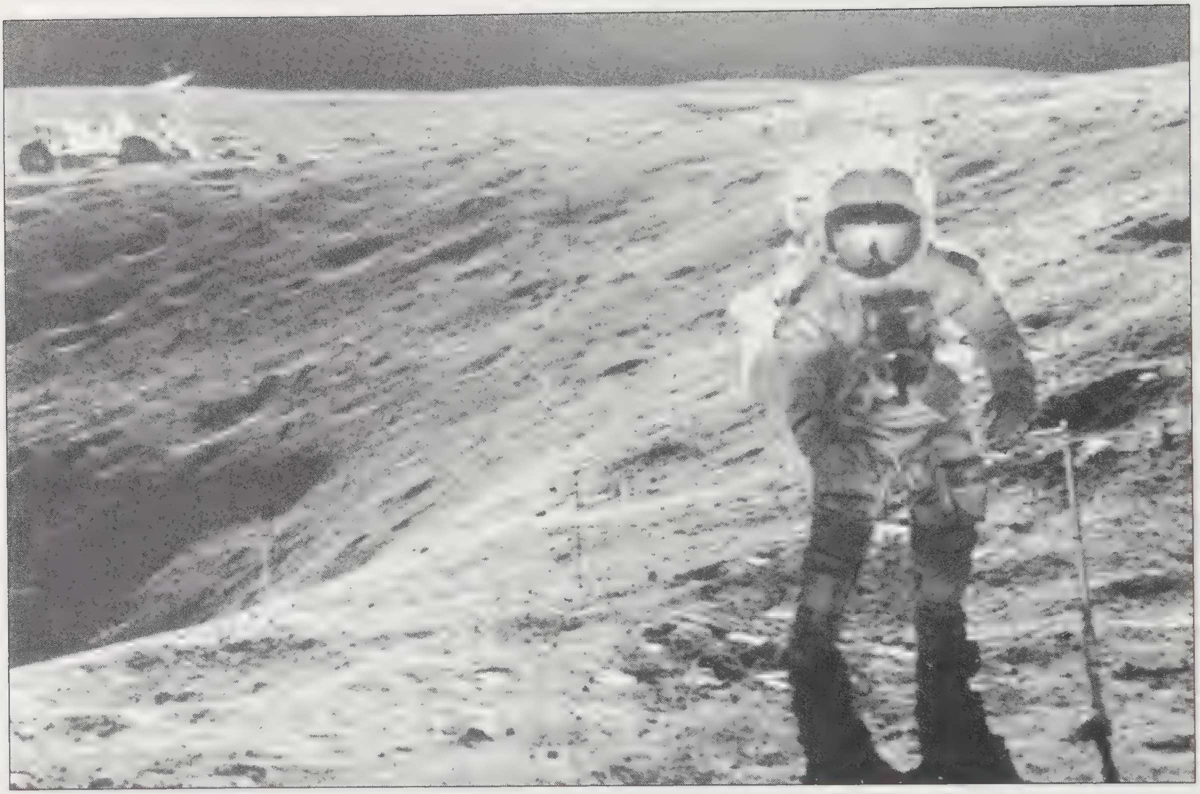


Figure 3-9 *This moonwalking astronaut could be exploring a similar crater on Mars sometime in the next two decades. A search for Martian fossils would be a key element of any manned Mars mission.*

SPACE STATIONS AND COLONIES

Space Simulator features some very sophisticated space stations. Though all four are based on existing designs, only one, *Space Station Freedom,* is actually scheduled for future deployment. Unfortunately, *Freedom* is currently facing severe budget problems. Development continues, but final specifications, dates for construction, and deployment are pending.

Someday, however, permanent manned orbital "villages" will become a reality. *Freedom* and other future space stations will be different from those of the past in many ways. For one, they'll be far bigger—so big, they won't be launched intact. Instead, shuttles will ferry them up, piece by piece. Then astronaut-engineers will construct them in space. They'll be designed for comfortable living during long stays.

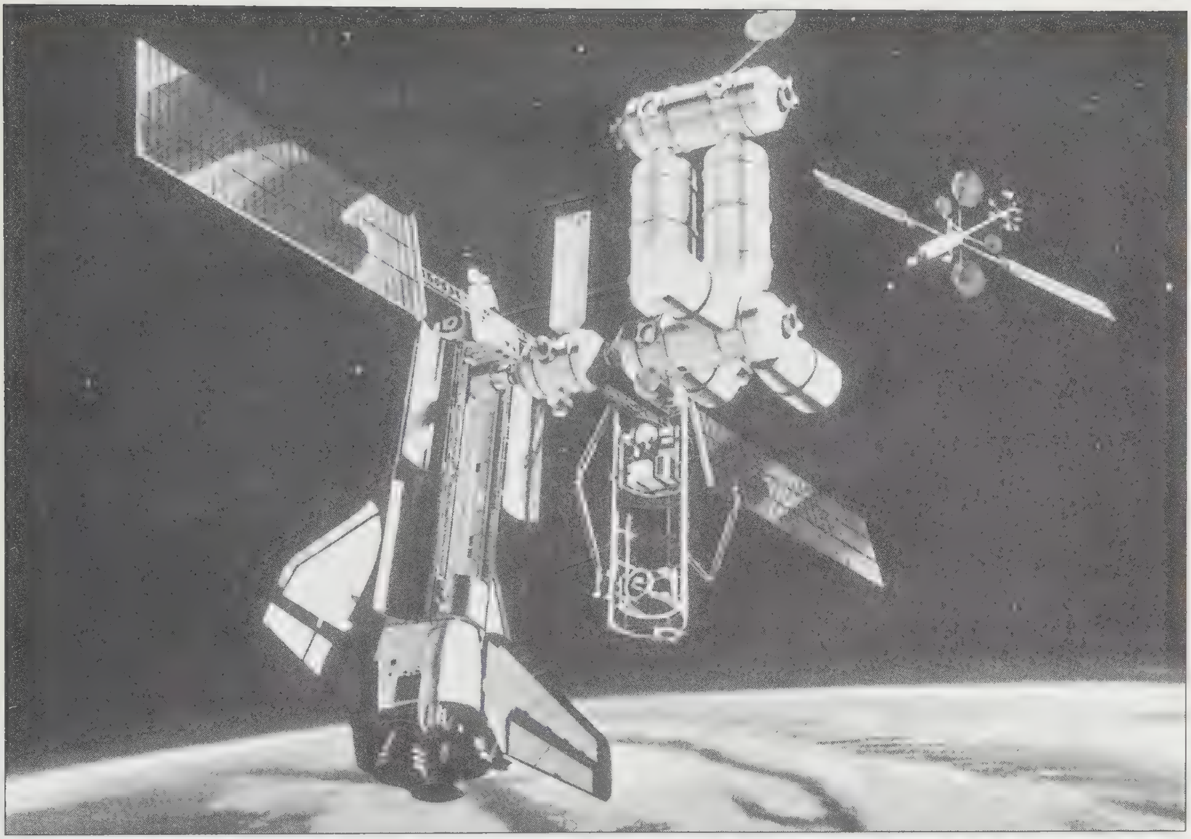


Figure 3-10 *This NASA artist's concept of a permanent space station closely matches the final design of* Space Station Freedom. *Here, a space shuttle on a resupply mission docks with the facility.*

These permanent installations will also feature versatility. They'll combine numerous functions—observatory, test laboratory, factory, perhaps even a launch facility for missions into deeper space. Some scientists envision huge orbiting power plants that can convert raw, unfiltered sunlight directly into electricity, then zap it down to Earth in the form of a powerful microwave beam.

The *Freedom* design features a horizontal boom about 500 feet long. A cluster of housing modules, a solar panel array, and dozens of small experiment packages will be attached to the boom. Current plans are for four separate modules—a NASA-built "Habitat" of private quarters for astronauts, with a "NASA Laboratory" attached just below it for experiments; an unmanned

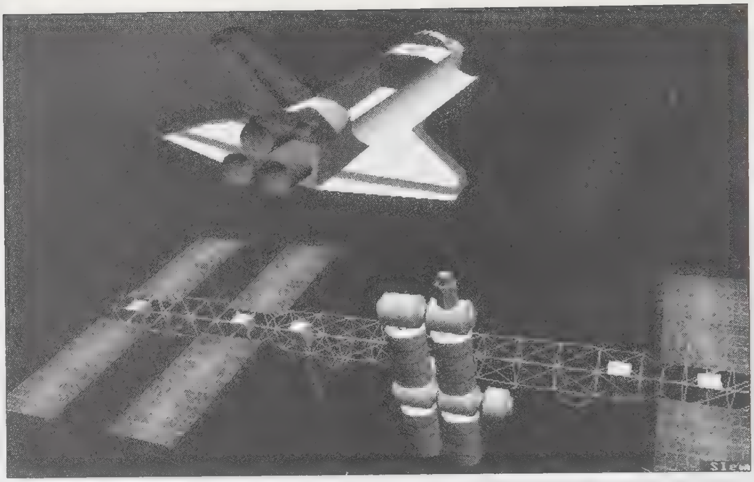


Figure 3-11 *The U.S. space shuttle fleet will make frequent flights to resupply* Freedom *and rotate the crew. This dramatic shot right from* Space Simulator *depicts such a rendezvous.*

"Experiment Unit" for self-contained experiments, built by Japan's National Space Development Agency (NASDA); and the "Columbus Laboratory" built and run by the European Space Agency (ESA), a joint project of Austria, Belgium, Denmark, Germany, Ireland, Italy, the Netherlands, Norway, Spain,

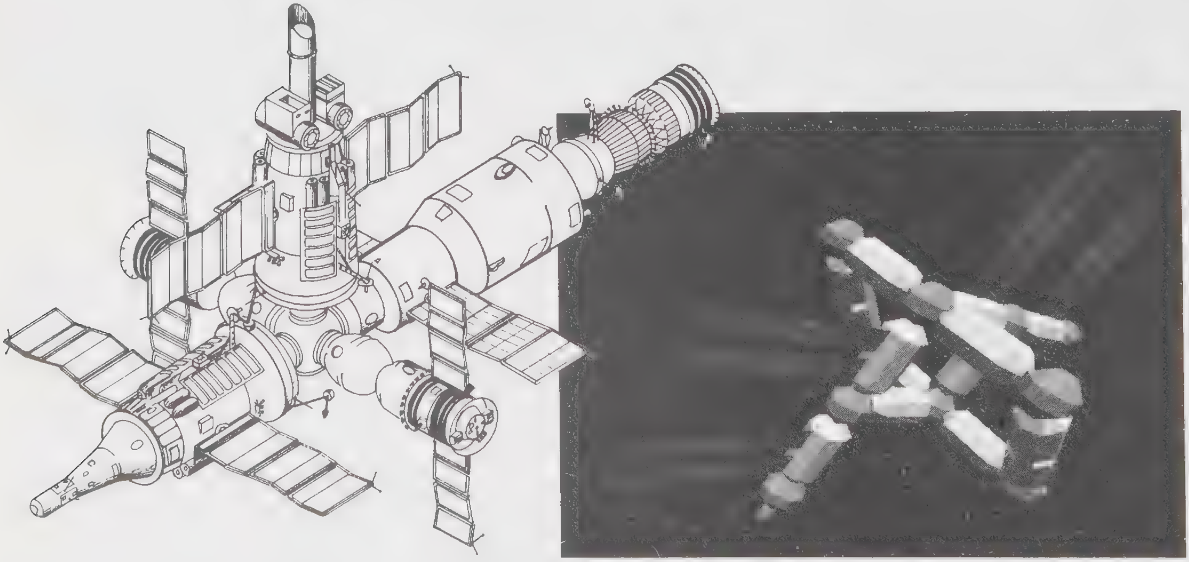


Figure 3-12 *The* Lunar Orbiter *space station in* Space Simulator *is based on the modular design of the actual Russian* Mir *space station complex, shown above. The "building block" concept is based on six docking ports so that* Soyuz *spacecraft can dock, and additional lab units added.*

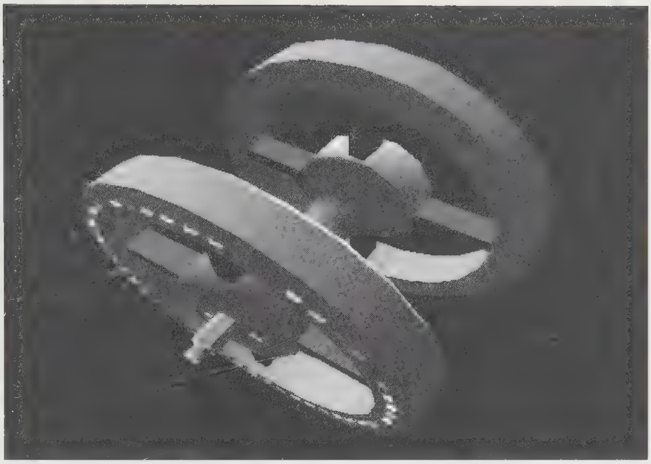


Figure 3-13
Space Simulator*'s rotating double-wheel space station,* Ring Station One, *is based on a familiar design. Many futurists see wheel or donut-shaped stations as the best way to distribute an artificial Earth-like gravity (using the centrifugal force of rotation) evenly along interior surfaces.*

Switzerland, and the United Kingdom. Finally, a Canadian-built mobile servicing center featuring a large robotic arm (like the one the Canadians built for the U.S. space shuttle) will slide the length of the boom, grabbing and moving large equipment when necessary.

Future space station designs include models similar to the one seen in the movie *2001: A Space Odyssey*, or to the Ring Station in *Space Simulator*, for that matter. Double-wheel-shaped, rotating structures like these would use centrifugal force to create an artificial gravity. Some scientists go even further, envisioning vast rotating space colonies that provide homes for thousands, even millions of people.

For example: Princeton University physicist Gerard K. O'Neill has designed mammoth space communities, such as the ambitious *Island Three*, which features a pair of cylinder-shaped living habitats, each measuring 4 miles in diameter and 20 miles in length! Another design, championed by scientist T. A. Heppenheimer, is called the Stanford torus. This colony looks like a fat spoked wheel with a circumference of 3 miles. Its rotation rate of 1 revolution per minute would provide a comfortable gravity for its 10,000 inhabitants.

Like Mars mission proposals, the space station/colony concept faces stiff economic challenges in the near term. Famed space scientist James Van Allen (for whom the Van Allen Belt is named) believes that a space station would siphon too much money away from unmanned projects that are far more worthwhile. "The overwhelming majority of scientific and utilitarian achievements in space," he says in *Living in Space: Opposing Viewpoints*, "have come from unmanned, automated, and commandable spacecraft."

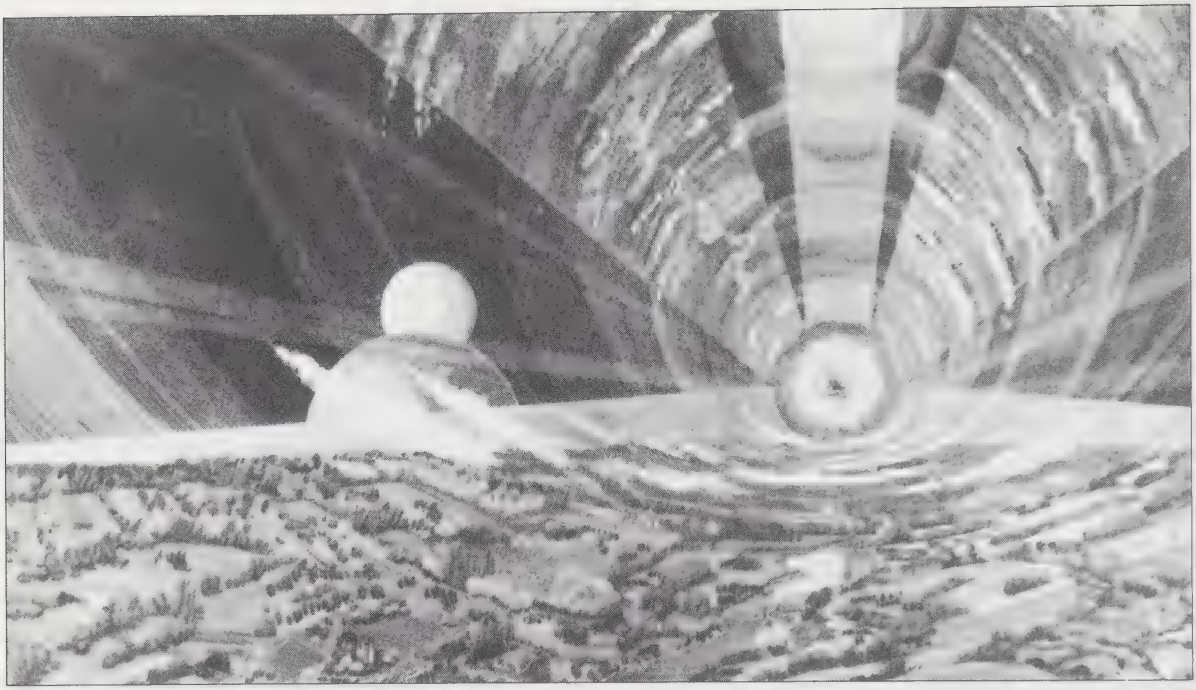


Figure 3-14 *One proposed space colony design features a pair of cylinders 20 miles long and four miles in diameter. Each cylinder rotates to provide artificial gravity. Note the three separate "habitat" strips running the length of the cylinder.*

DEEP SPACE: BEYOND OUR GRASP?

Remember the opening scenario of this chapter? Suppose SETI really did receive a message—an invitation, even—from a civilization located in deep space. What if that message originated in a galaxy such as Andromeda, 2.2 million light-years away? And what if the senders weren't so kind as to include a *superluminal* (faster than light) starship as part of the deal? A mission to Andromeda, even at the speed of light, would span about 30,000 human lifetimes.

How the heck would we get there?

Are we bound by the speed of light?

Possibly. But just as Newtonian physics failed to encompass notions of relativity and quantum theory, so perhaps might today's physics give way to some new "magic" that enables us to warp at will across the vast interstellar voids, or perhaps even slip between the sheets of time itself.

SUPER FUEL: NUCLEAR FUSION AND ANTIMATTER

Sure, it would be a lot of fun to warp around the space-time continuum, going where no man has gone before, and all that. But realistically speaking, such a breakthrough is unlikely to occur during our lifetimes. Better to focus on the development of superfuels that lie just over the horizon, fuels that would propel us many times faster than our current chemical fuels can. One such fuel, nuclear fission, is already at hand. But its lethal by-product, long-term radiation, makes it objectionable to many as a fuel source.

One viable alternative is nuclear fusion, the type of atomic reaction that powers the Sun. Instead of splitting atoms, as nuclear fission does, fusion actually causes atoms to join together. This leaves none of the leftover radioactive waste that makes nuclear fission so dangerous. In one speculative design of a fusion rocket, hot plasma generated by a fusion reactor would be expelled—leaked, actually—from one end of the spacecraft, then focused into a directed exhaust jet by powerful magnetic mirrors.

Three of the spacecraft in *Space Simulator* are powered by fusion engines—the *Galactic Explorer*, with its twin fuel tanks of "hydrogen slush"; the *Bussard Ramjet*; and the awesome *Zander Freighter*, 100,000 metric tons of fusion-propelled majesty.

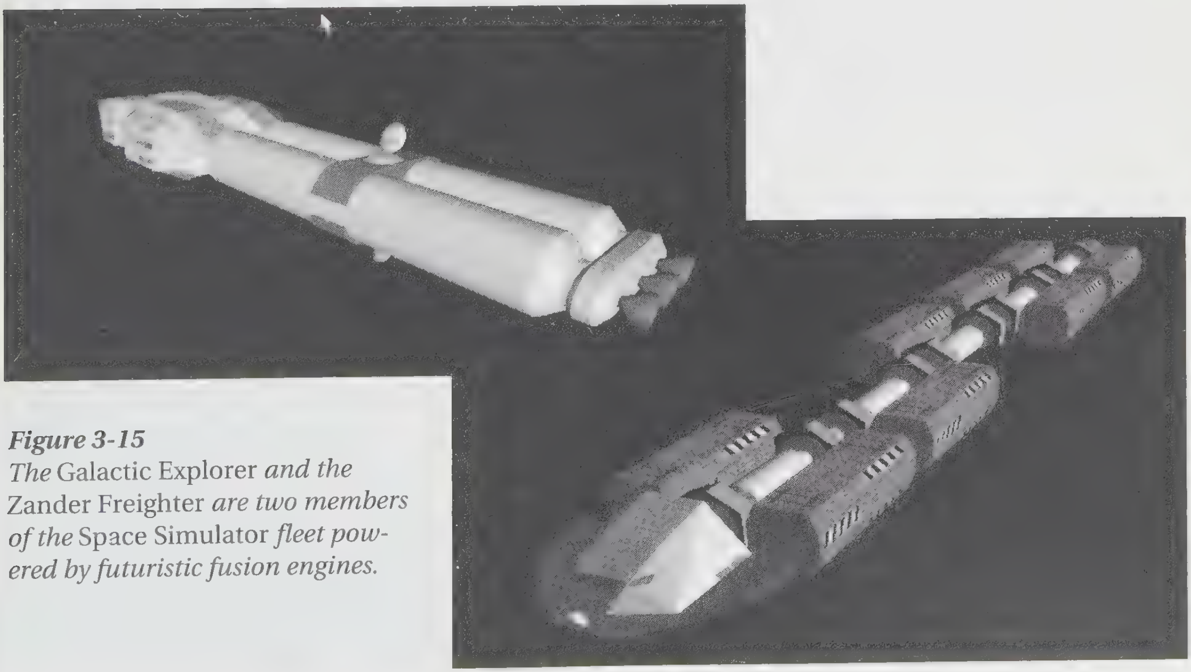


Figure 3-15
The Galactic Explorer *and the* Zander Freighter *are two members of the* Space Simulator *fleet powered by futuristic fusion engines.*

Antimatter propulsion offers even more dramatic, if more exotic, possibilities. For decades, scientists have known that every elementary particle in nature—proton, neutron, electron—has its antiparticle. Electrons, for example, have a negative charge. But antielectrons (known as positrons), with the same mass and spin as electrons, display a positive charge. There are also antiprotons and antineutrons.

When opposing particles are brought together, they "annihilate" one another, producing truly mind-boggling amounts of energy. Indeed, matter/antimatter annihilation produces energy a hundred times more efficiently than a fusion reaction. Physicist Robert L. Forward has shown that a few milligrams of antimatter (which he calls "mirror matter") could replace the energy of many tons of standard chemical propellant. The idea is so intriguing that the U.S. Air Force is funding research on antimatter, which former astronaut Michael Collins calls "the key to driving a star ship close to the speed of light" (from *The Starflight Handbook*).

Today, unfortunately, antimatter is very difficult to produce in anything more than microscopic amounts. In fact, the current cost of producing 1 milligram of antimatter (by smashing protons in a huge particle accelerator) is a somewhat prohibitive $100 billion. But while antimatter drives may be today's impracticality, they offer great promise for interstellar travel in the next century. Robert Powers, a Fellow of the Royal Astronomical Society, has said: "If the [antimatter] engine is developed, a small vessel . . . could make the trip to Alpha Centauri in only a few years."

Space Simulator's F-79 Galactic Fighter is powered by an antimatter propulsion system that provides a blistering 8 g's of acceleration.

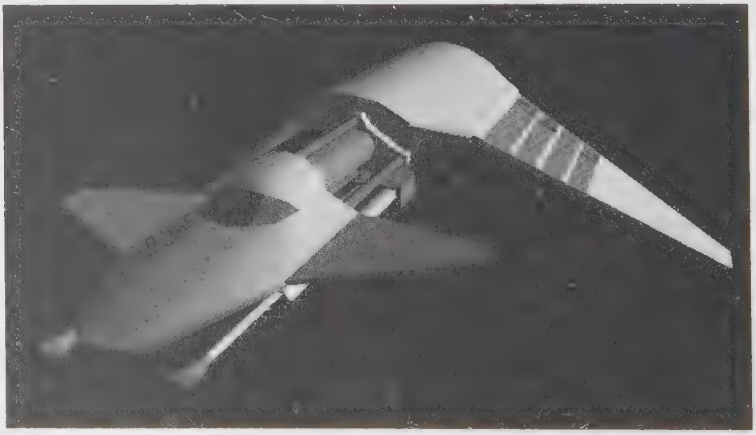


Figure 3-16 *Space Simulator's fictional* F-79 Galactic Fighter *features a powerful antimatter engine. While this propulsion system sounds like science fiction, it is based on current science reality.*

THE RAMJET

Even with such advanced propulsion fuels as those mentioned above, there remains the problem of carrying enough of the fuel for interstellar travel. For travel to distant star systems to realistically succeed, the rate of acceleration would need to remain at a constant 1 g. That would require a tremendous amount of energy expended over a period of years, even decades.

But imagine a ship that actually collects its own fuel as it travels through space. Is such a craft possible? In 1960, scientist R. W. Bussard published a now-famous article (entitled "Galactic Matter and Interstellar Spaceflight") in which he proposed an interstellar spacecraft called a "fusion ramjet." This craft would be powered by a fusion engine fueled by hydrogen, the most common form of matter in the cosmos. Bussard's fusion ramjet is the very one you find in *Space Simulator.*

The *Bussard Ramjet* relies on a huge magnetic funnel called a ramscoop to collect interstellar hydrogen, then beam the high-energy particles aft into the ship's fusion reactor. With such a steady supply of fuel, and accelerating at the steady rate of 1 g, a fusion ramjet could approach the speed of light within a year.

Other space theorists have proposed even more exotic variations. A quantum ramjet could ingest quantum fluctuations in the energy of the interstellar vacuum—microscopic bits of mass that pop in and out of existence throughout the universe. *The Starflight Handbook*, by Mallove and Matloff, posits that "if a quantum starship could tap only a very tiny fraction of the theoretically available mass/energy of the vacuum, it could accelerate rapidly to relativistic velocities."

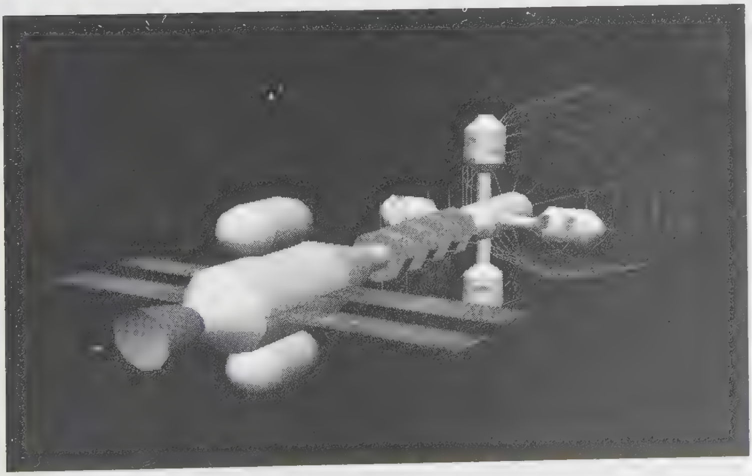


Figure 3-17 *That huge, funnel-like "ramscoop" on the front of the* Bussard Ramjet *collects the most common form of matter in the cosmos, hydrogen, then feeds it as fuel to the ship's nuclear fusion engine.*

Figure 3-18 Yes, there are a lot of stars in a spiral galaxy such as this one, designated NGC 4565. But many scientists believe such visible objects make up only 1 to 10 percent of the universe; the rest consists of "dark matter."

Another model—the Dark Matter Ramjet—could collect particles of the "dark matter" that astrophysicists now say make up anywhere from 90 to 99 percent of the universe. Indeed, this dark matter is so plentiful that a starship which converts it to propulsive energy would have a nearly limitless source of fuel.

HYPERSPACE: WORMHOLES AND "THE BLACK HOLE EXPRESS"

You've seen it in *Star Trek*—"Warp speed, Mr. Sulu"—or the dramatic jump to hyperspace in *Star Wars.* It looks cool, doesn't it? But what does true science say about such possibilities? Is the speed of light a sacred barrier? Is superluminal flight even remotely possible?

Recently, mathematical relativists at CalTech actually constructed a space-time geometry in which "warping" from one part of the universe to another is theoretically possible. Physicists, working from Einstein's theories of relativity, had long suggested the possibility that spacetime is riddled with shortcuts—called *wormholes*—that might allow passage across not only vast distances, but perhaps also across time itself. The CalTech team found that many of these "hyperspace" connections—according to the physics, anyway—would be large and conceivably traversible by human beings.

In John Gribbin's *Unveiling the Edge of Time*, the author examines wormhole theories and other notions of hyperspace portals being discussed quite seriously today by eminent physicists, and he concludes:

> To be sure, the physical requirements appear contrived and implausible. But that isn't the point. What matters is that there seems to be nothing at all in the laws of physics that forbids travel through wormholes. The science-fiction writers were right—hyperspace connections do, at least in theory, provide a means to travel to distant regions of the Universe without spending thousands of years pottering along through ordinary flat space at less than the speed of light.

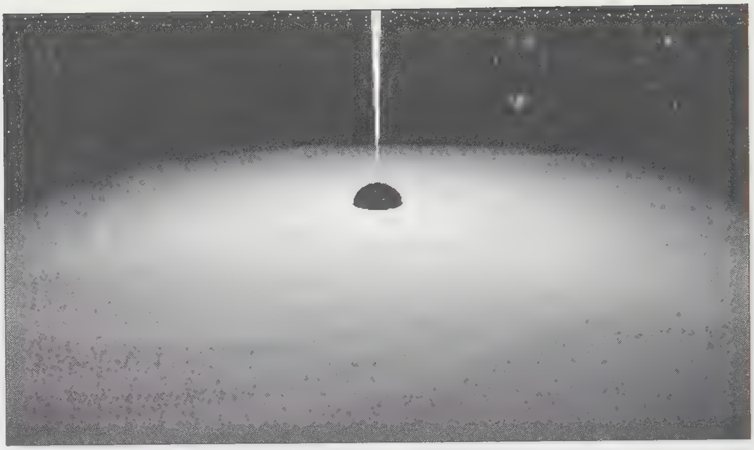
The CalTech calculations, as well as those of most other theorists, rely on the basic assumption that *black holes* can provide doorways to the stars. A black hole is formed by the collapse of a massive star after it explodes in a supernova. As the star collapses inward, the density of its mass becomes so great that it sucks in everything nearby. The resulting gravity is so powerful that nothing—not even radiant light—can escape. Hence the term *black hole*.

Black holes were once merely hypothetical concepts built purely on mathematical equations and theory. But in the spring of 1994, the newly repaired Hubble space telescope confirmed for the first time the existence of a massive black hole at the center of a giant galaxy called M87, ending a decades-long quest for definitive proof.

The orbiting observatory clearly revealed the powerful gravitational force at the heart of M87, which sits more than 50 million light-years away in the constellation Virgo. Astronomers had long suspected a lurking black hole there, but Hubble's new corrective lenses (installed during a space shuttle mission in December 1993) showed the maelstrom surrounding the central object so sharply that scientists were able to "weigh" it. This is done by measuring the inward velocity of the material rushing into the dark, voracious monster.

Because the immense gravity of the black hole sucks all nearby stars, planets, and other cosmic material into it, this stuff forms a pancake-shaped whirlpool (called the *accretion disk*) that resembles water going down a bath-

Figure 3-19 *Here is* Space Simulator*'s version of the cosmic powerhouse at the heart of the Milky Way. The black hole at the galactic core sucks all surrounding matter and energy toward it in a spinning accretion disk, while squirting energy outward from the poles in great jetting streams.*



tub drain. In this whirlpool, matter compresses to great density, collides, heats up, and forms a spinning disk of spewing, jetting hot gases.

Eventually, the swirling matter crosses a point of no return called the *event horizon.* Once it crosses this one-way threshold, the matter is compressed into an almost unimaginable density, occupying such a small space that, for example, a black hole merely 4 miles across would contain enough matter to equal the mass of the Sun.

Thus, despite being about 2,000 times smaller than Earth, this relatively tiny black hole would feature the mass (and powerful gravity) of about 300,000 Earths! By comparison, the giant black hole at the heart of the M87 galaxy occupies a space the size of Earth's Solar System, and contains the mass of about 3 billion Suns. That's a lot of gravity.

According to theorist Stephen Hawking and others, the awesome power of a black hole warps the very fabric of space and time. Within its inescapable boundaries, normal time and space come to a halt. The known laws of physics do not apply. Thus, some physicists see these singular objects as possible passageways through space and time. Eminent scientists such as Carl Sagan and Russian astrophysicist N. S. Kardashev have even imagined black holes as "stations" on an intergalactic "subway system." As *The Starflight Handbook* (Mallove and Matloff) describes it, "spaceships [would] approach a black hole along certain well-defined critical trajectories, leave normal space-time, and emerge elsewhere or 'elsewhen.'"

Of course, there would be some significant drawbacks to using black holes as a transgalactic hyperspace subway. *The Starflight Handbook* also describes how Thomas Gold, a Cornell University astrophysicist, has deflated notions of black hole warping by pointing out that "an astronaut or spacecraft approaching a stellar mass black hole would be stretched catastrophically by severe gravitational tides." Gold suggests that the ship's occupants would soon find themselves elongated to the dimensions of a spaghetti noodle.

Ouch.

WHY GO OUT AT ALL?

OK, it's dangerous out there. You can't breathe. It's hotter or colder than the average rock can withstand. Black holes wait to pull you apart like taffy. Cosmic rays want to mess with your molecules in really horrible ways.

So why does mankind need the aggravation of space travel?

One reason for further space exploration may be this: We just can't help it. Maybe it's Darwinian. Maybe the dictates of survival have programmed our species to move, adapt, change, grow, and expand our environmental capabilities. Maybe our sense of wonder and curiousity is imbedded somewhere in the genetic code, part of the human evolutionary package.

Speaking in 1976 of the *Viking 1* journey to Mars, author Norman Cousins said:

> The question "Why explore?" pertains less to the *Viking 1* expedition in particular than to the nature of the human mind in general. We are here to consider not just the phenomenon of a journey to Mars but the phenomenon of intelligence. The fact that we can conceive of the inconceivable, and comprehend the incomprehensible, is perhaps the highest exercise of the human brain . . .

What's out there? Apparently, we just have to know.

A journalist once asked Wally Schirra, one of the original Mercury project astronauts, how humanity could possibly be served by taking very, very expensive trips to such barren, inhospitable places as the Moon or Mars. He agreed that "Mars and the Moon are two ugly islands." But then he said: "The point is to be able to say I've been there, I've set foot on them, and now I can go further to look for the beautiful islands."

Among the many things that *Space Simulator* does, it gives you a tantalizing glimpse of beautiful islands. There's undoubtedly a few billion of them out there just waiting for Robinson Crusoe to wade ashore and pitch his tent.

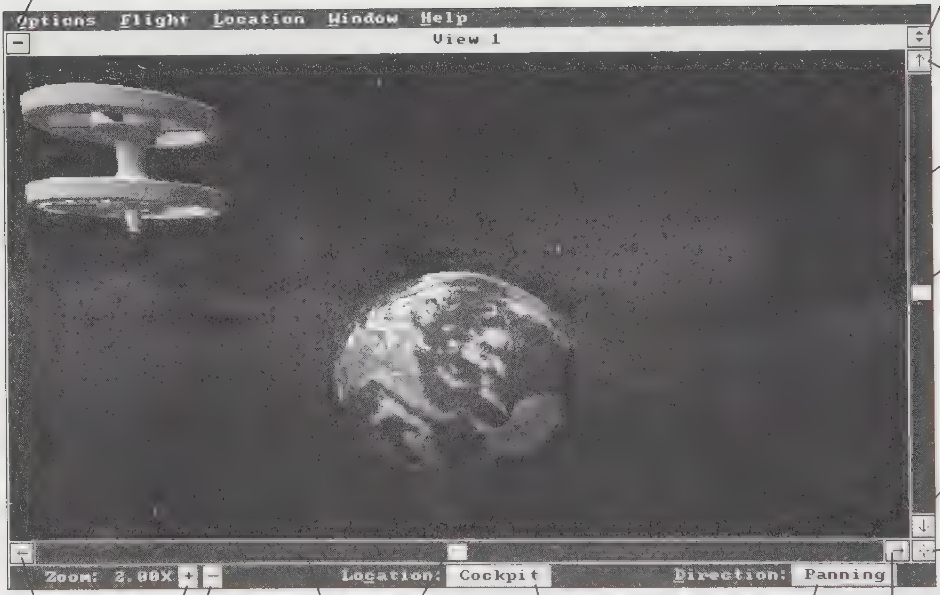
Figure 3-20
With spectacular celestial displays such as these, is it any wonder humanity feels compelled to explore the cosmos? Above: *A star cluster in Serpens.* Right: *The Ring Nebula.*

Part Two

Chapter 4

View Tools

Mission: Windows to the Solar System


Options Flight Location Window Help
View 1
Zoom: 2.00X + −
Location: Cockpit
Direction: Panning

Close window

Maximize view (Ctrl + F10)

Pan up (Alt + ↑)

Vertical panning bar

Center view (vertical)

Pan down (Alt + ↓)

Reset button (centers view horizontally and vertically (Alt + keypad 5))

Pan left (Alt + ←)

Zoom out (keyboard −)

Center view (horizontal)

Direction button (toggles between Panning/Tracking views (D))

Pan right (Alt + →)

Zoom in (keyboard =)

Horizontal panning bar

Location button (toggles between Cockpit/Chase/Assigned views (S))

Figure 4-1 View Tools. *Changing your perspective has never been easier. With a few clicks, you can see anywhere in the vicinity of your spacecraft. (Equivalent keystroke commands are listed in parentheses.)*

In this chapter you'll take your first look at the *Space Simulator* universe through the program's remarkable "windows." I'll start with a quick review of all the view tools, the Window menu, and the video recording and editing features at your disposal. Then you'll launch your first mission, a tour of the Solar System—a tour that will not only dazzle you, but also familiarize you with all of *Space Simulator*'s custom viewing options.

Note to Keyboard Users: In the main text of this chapter, I assume that you use a mouse for button and menu selections. However, I've included keystroke equivalents in parentheses when appropriate.

VIEW TOOLS

In general, *Space Simulator*'s set of view tools (as shown in Figure 4.1) is quite easy to use. Though some users (including *yours truly*) may experience early confusion with certain aspects of Panning and Tracking modes, this will clear up once you've used them a bit.

Active/Inactive Windows

A window must be *active* before you can use the keyboard View tools to change that window's view. To make a window active, simply click on it. The active window is the one with the light gray title bar across the top. Any window with a blue title bar is inactive.

Zoom

A powerful view tool, the Zoom button lets you increase or decrease the magnification of the view in the active window. For a faster change, press Shift + equals sign (=) to double to zoom factor, or Shift + hyphen (-) to halve it.

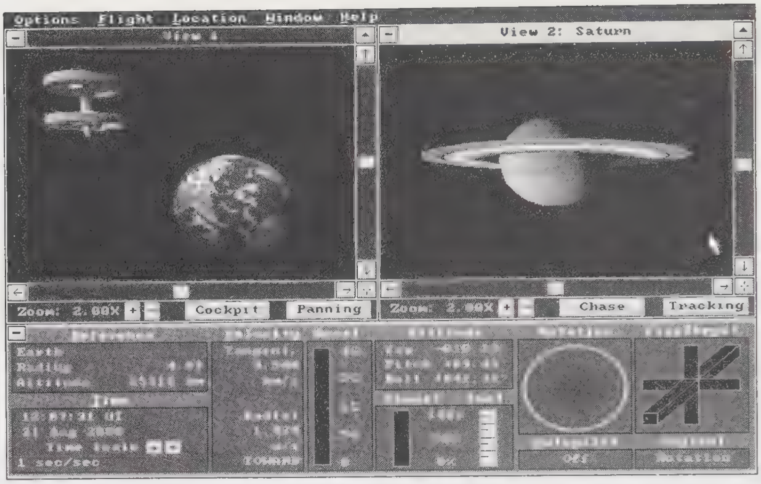

Options Flight Location Window Help
View 1
View 2: Saturn
Zoom: 2.00X
Cockpit
Panning
Zoom: 2.00X
Chase
Tracking

Figure 4-2 Active Window. *The active window has a light gray title bar; inactive windows have dark blue title bars. In this shot, the right-hand window (View 2: Saturn) is the active window.*

View Location: Cockpit, Chase, Assigned

Click the Location button (S) to toggle your active window between three different view locations: Cockpit, Chase, and Assigned.

- Cockpit gives you the view from inside your spacecraft, looking out.
- Chase centers your view on that View window's current tracking object from an imaginary chase craft. To change the tracking object, press T.
- Assigned lets you see the view from any object in the *Space Simulator* universe. To select an Assigned view location for the currently active window, press the A key.

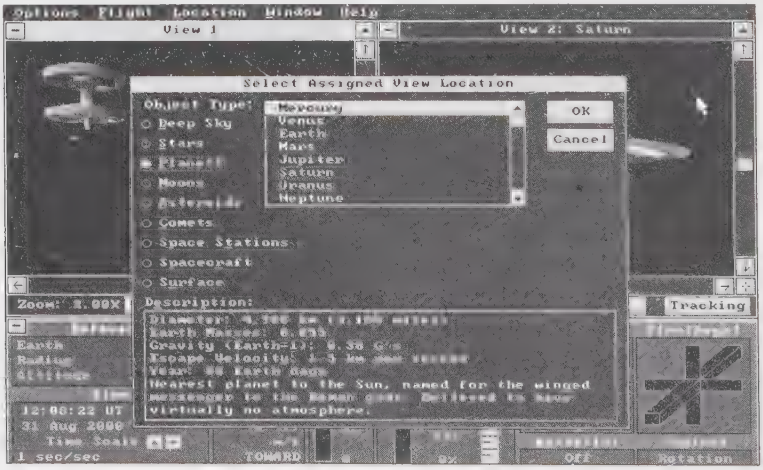

Options Flight Location Window Help
View 1
View 2: Saturn
Select Assigned View Location
Object Type:
○ Deep Sky
○ Stars
● Planets
○ Moons
○ Asteroids
○ Comets
○ Space Stations
○ Spacecraft
○ Surface
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
OK
Cancel
Description:
Tracking

Figure 4-3 Assigned View. *Press* A *to bring up this dialog box. Choose an object type by clicking the corresponding button. Then select the new Assigned view location from the list.*

TWO CRITICAL KEYS TO HAPPY VIEWING

Before we go any further, here are two very important points I want to emphasize about your viewing options:

1. **Your three view windows—View 1, View 2, and Map View—operate independently of one another.** Changes made to one window will have absolutely no effect on the other two windows. So if you want to make wholesale changes, you'll have to change each window separately.
2. **The three view locations available in both View 1 and View 2—Cockpit, Chase, and Assigned—also operate independently of one another.** Again, changes made in one view location will not effect the view in the other two locations, even though they're operating within the same view window.

The point here is that you can have *six completely different shots* (plus a seventh, the Map View shot) set up in your windows, with each shot accessible by a click or two of the mouse. It's a flexible and very powerful viewing system.

View Direction: Panning and Tracking

Click the Direction button to toggle the view of your active window between two different modes: Panning and Tracking. As the name implies, "view direction" is the direction you are looking, not the direction you are traveling.

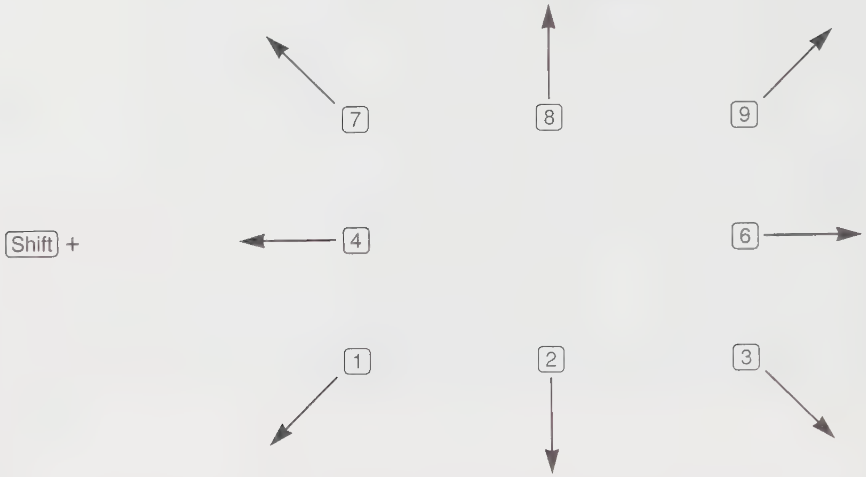
Panning Mode

Panning mode lets you swing your view around in a full circle, looking outward from your current viewing location.

- To *pan*, click anywhere along the horizontal and vertical panning bars, or press Alt + the arrow keys.
- To *power pan* horizontally to one of eight possible directions, hold down Shift and press the appropriate keypad key (see the diagram on page 104).

Note: You can only power pan horizontally.

Power Panning
(Panning mode)



Tracking Mode

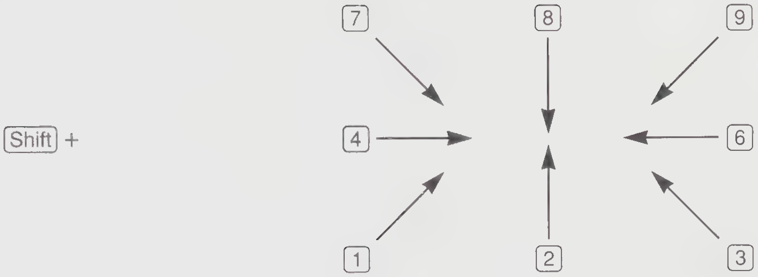
Tracking mode locks the view of each view location—Cockpit, Chase, and Assigned—onto a designated *tracking object.* No matter which way you maneuver through space, your window view remains fixed in relation to the tracking object.

Tracking mode also allows you to do the following things in Chase view:

- Get a close-up look at two tracking objects simultaneously—say, Earth and Saturn— that are quite distant from one another. (They must, however, generally be in the same region of space.)
- Use the panning bars to rotate completely around the tracking object, looking in at it the whole time.
- Power pan with the horizontal panning bar to look in at the tracking object from one of eight possible directions. Hold down Shift and press the appropriate keypad key (see the diagram on page 105).

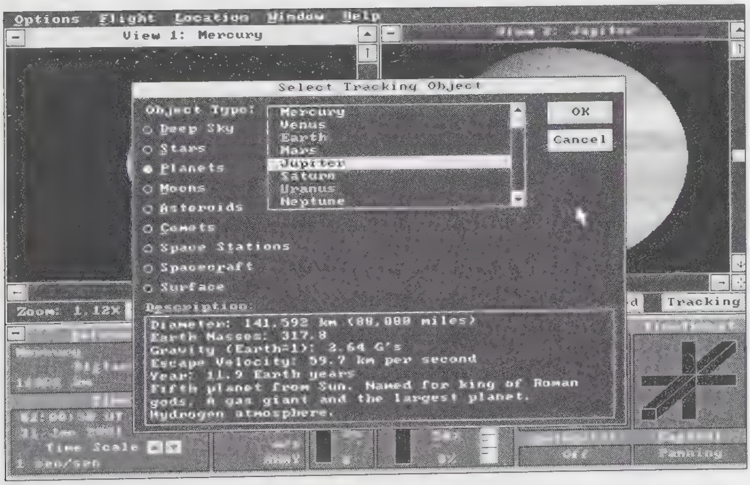
Note: You can only power pan horizontally.

Power Panning
(Tracking mode)


Shift +
7
8
9
4
6
1
2
3

Since *Space Simulator* maintains a tracking object for each view location, first make sure you are at the desired view location—Cockpit, Chase, or Assigned. To select a new tracking object:

1. Press T to display the Select Tracking Object dialog box.
2. Click on the object type you want; you'll get a list of objects.
3. Click on the object you'd like to track. Then click on OK.


Options Flight Location Window Help
View 1: Mercury
Select Tracking Object
Object Type:
○ Deep Sky
○ Stars
● Planets
○ Moons
○ Asteroids
○ Comets
○ Space Stations
○ Spacecraft
○ Surface
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
OK
Cancel
Zoom: 1.12X
Tracking
Time Scale

Description:
Diameter: 141,592 km (88,000 miles)
Earth Masses: 317.8
Gravity (Earth=1): 2.64 G's
Escape Velocity: 59.7 km per second
Year: 11.9 Earth years
Fifth planet from Sun. Named for king of Roman gods. A gas giant and the largest planet. Hydrogen atmosphere.

Figure 4-4 Select Tracking Object. *This dialog box lets you select a tracking object for each view location—Cockpit, Chase, and Assigned.*

Tracking and Panning in Chase View—

Perhaps the most complicated aspect of *Space Simulator*—at the beginner level, anyway—is learning how to manipulate the window system to get the view you desire.

Most of the time, I find myself using Chase/Tracking view in my windows because it allows me to control the camera better. I can get an object fixed in my sites, then swing the "chase craft" around it for dramatic views. *Space Simulato*r's fleet is rendered in such fine detail that I like to set up close angle shots of spacecraft framed by some celestial wonder in the background—a spinning planet, a fiery star, a neon-bright nebula, or whatever else looks good.

Of course, it's also fun to just sit in the Cockpit and let space zoom by in Panning mode. But generally, the human eye likes a fixed reference object—particularly in outer space, where often there's nothing out there but a spacecraft and a starfield.

Let's set up a camera in Chase View, then move it around a bit to see:

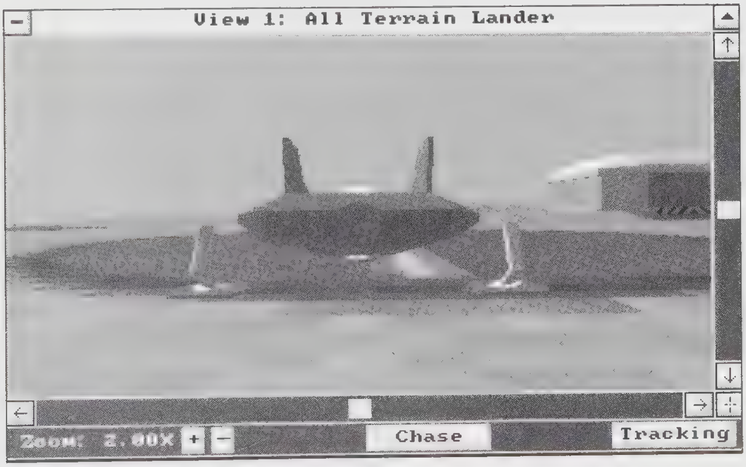
- how Tracking and Panning modes work
- how they affect one another

1. Select Spacecraft from the Flight menu and select the All-Terrain Lander.
2. If your spacecraft is not your current Tracking Object, press T. Under Object Type, select Spacecraft, then choose the All-Terrain Lander. (It should be the only ship listed.)
3. Change the Location to Chase.
4. Center the panning bars for both viewing directions:
    - Set the Direction to Panning mode, then click the Reset button (lower-right corner)
    - Now toggle the Direction to Tracking and click the Reset button again.
5. Select Surface from the Location menu and choose Mars Base Marineris from the file box list. Click OK.

There's a good chance you'll arrive at a dark Mars Base. If so, increase the Time Scale a few clicks to speed up the Martian sunrise. When day comes, reduce the Time Scale back down to 1 sec/sec.

6. Select Arrange from Window menu.
7. Under Window Options, be sure the selected option is Menu Bar and Windows.
8. Activate (put an "X" in) the View 1 box. De-activate (remove any "X" from) the View 2, Map View and Instrument Panel boxes. Click OK.
9. If your View Tools are not active, select Show View Tools from the Window menu to toggle them on.

You should now see this on your screen:



Now let's do some camera work. When you slide the panning boxes around to change the Chase camera view, the camera movement is different for Tracking and Panning modes:

Tracking and Panning in Chase View—

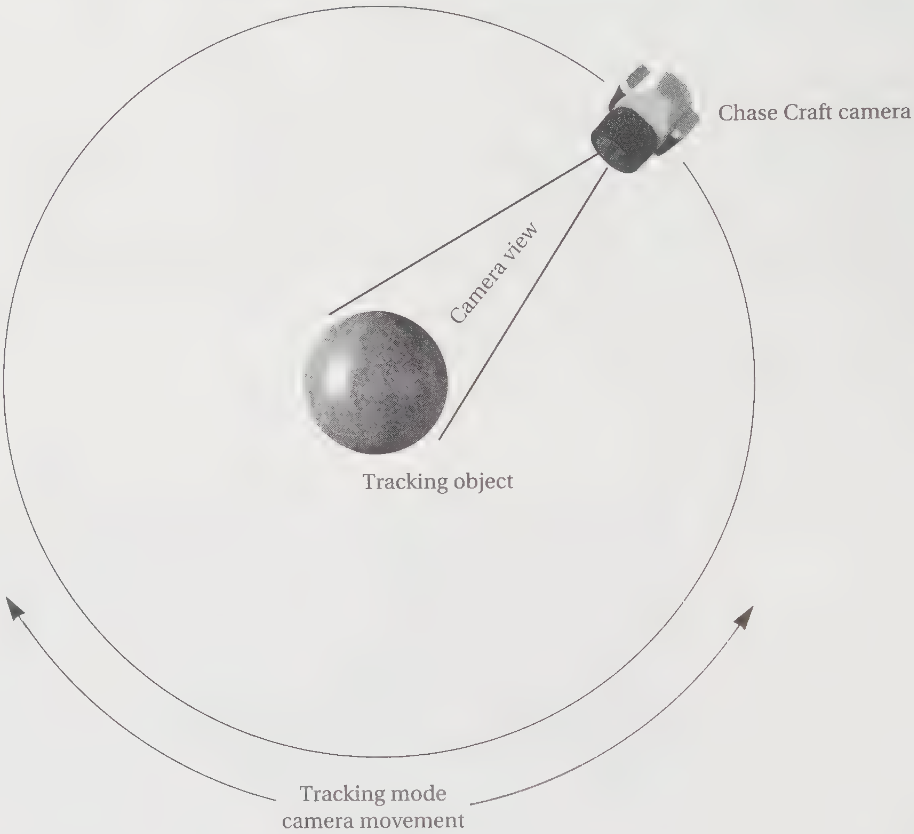
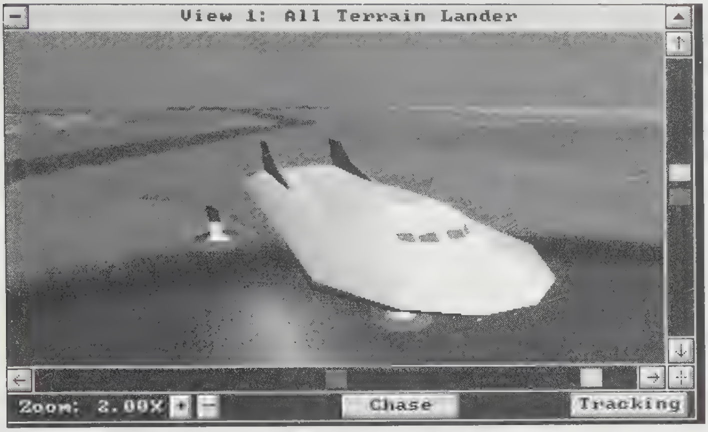
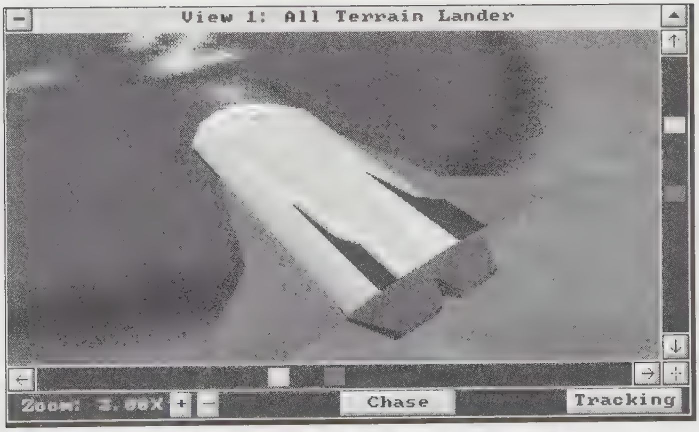
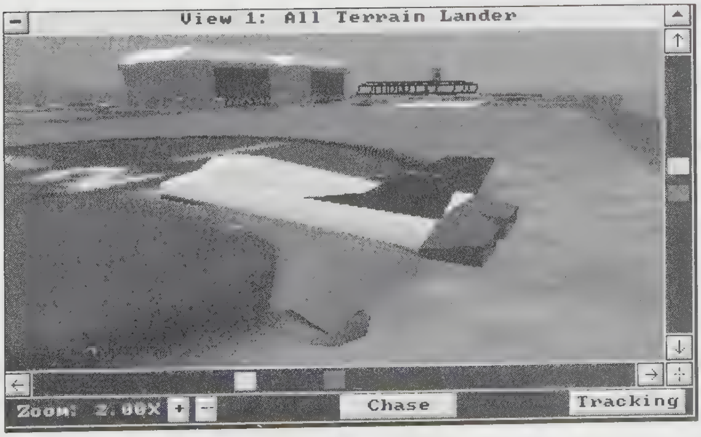

Chase Craft camera
Camera view
Tracking object
Tracking mode
camera movement

Figure 1 *Tracking Mode Camera Movement*

In Chase/Tracking mode, your "chase craft camera" swings around your designated tracking object (in this case, the All-Terrain Lander) at a fixed distance, as if attached to the object by a string. Imagine a sphere around the tracking object. The camera can be moved anywhere on that sphere's surface by using the horizontal and vertical panning bars, as in the following shot sequence:


View 1: All Terrain Lander
Zoom: 2.00X
+
−
Chase
Tracking


View 1: All Terrain Lander
Zoom: 3.00X
+
−
Chase
Tracking


View 1: All Terrain Lander
Zoom: 2.00X
+
−
Chase
Tracking

Note that however far you slide the panning boxes horizontally or vertically, the camera view remains centered on the tracking object. As the camera makes any Tracking mode movement, its angle toward the tracking object remains the same. Now try this:

10. Leave your panning boxes in an uncentered position on the vertical and horizontal panning bars, then switch your View Direction to Panning mode.

Notice how the horizontal and vertical panning boxes both reset to the center positions on the bars? When you switch between Panning and Tracking modes, the panning bar settings stay the way they were last set. To illustrate:

11. Switch back to Tracking again. Note how the panning boxes jump back to the positions in which you left them.
12. Switch back to Panning mode again.

In Chase/Panning, unlike in Chase/Tracking, the camera swivels while remaining fixed in one spot. When the panning bars are centered, the camera angle is directly at the tracking object. But slide the panning boxes and your chase camera swivels, changing the angle of the camera to the tracking object. (See Figure 2.) By combining horizontal and vertical panning, you can aim the "lens" in any direction.

Once again: In Tracking Mode, the camera moves around the tracking object at a fixed distance as if attached to it by a string, and the angle of view from camera to tracking object remains constant. In Panning Mode, the camera stays in a fixed position, but swivels its viewing lens around in any direction you want.

Now let's see how Panning and Tracking modes can affect one another:

13. In Panning mode, use the horizontal panning bar to swivel the view to the right, angling away about 45 degrees from the All-Terrain Lander until only the tip of the spacecraft's tail remains in the picture.
14. Now switch back to Tracking mode.

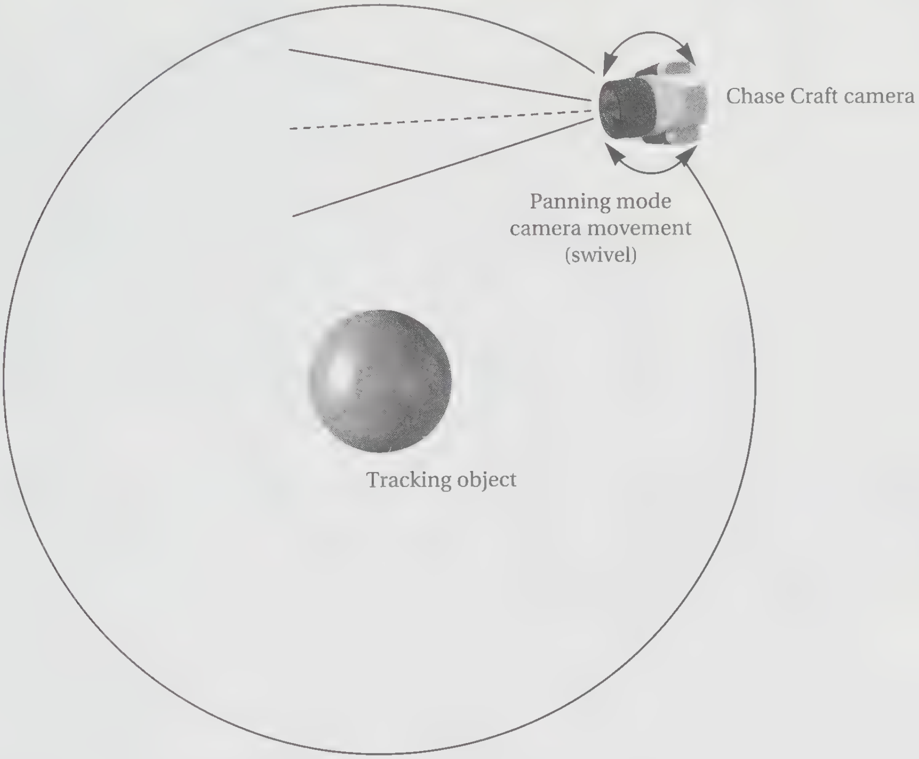

Chase Craft camera
Panning mode
camera movement
(swivel)
Tracking object

Figure 2 *Panning Mode Camera Movement*

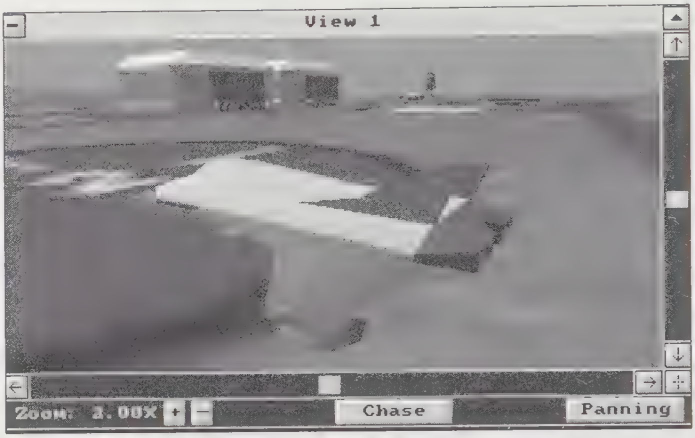
Note that although the panning bars return to the way they were set when you left Tracking mode earlier, the picture doesn't! Your pan to the right is the new starting point for your Tracking mode shot. To further illustrate this:

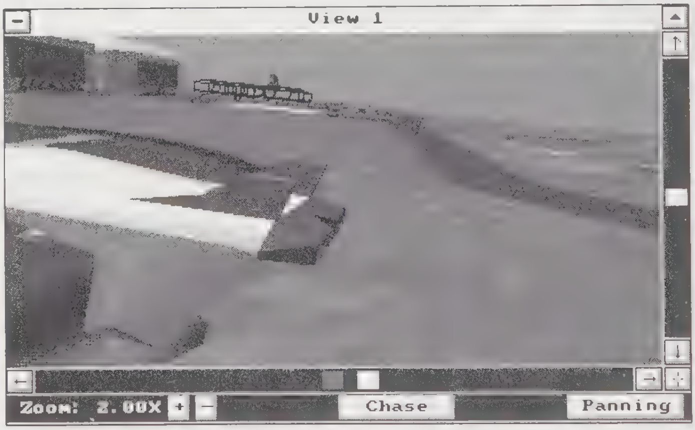
15. Click the Reset button.

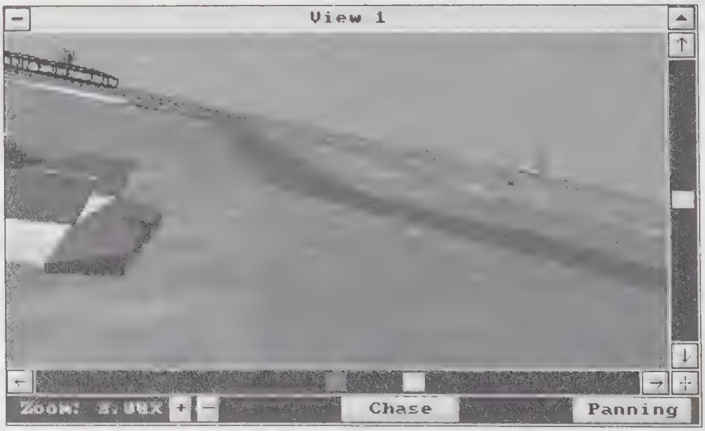
Your panning bars "center" your view, but not on your spacecraft! What's happening?

When you swivel your camera 45 degrees away from the All-Terrain Lander in Panning mode, it retains that angle away when you switch back to

Tracking and Panning in Chase View—


View 1
Zoom: 2.00X
+
−
Chase
Panning


View 1
Zoom: 2.00X
+
−
Chase
Panning


View 1
Zoom: 2.00X
+
−
Chase
Panning

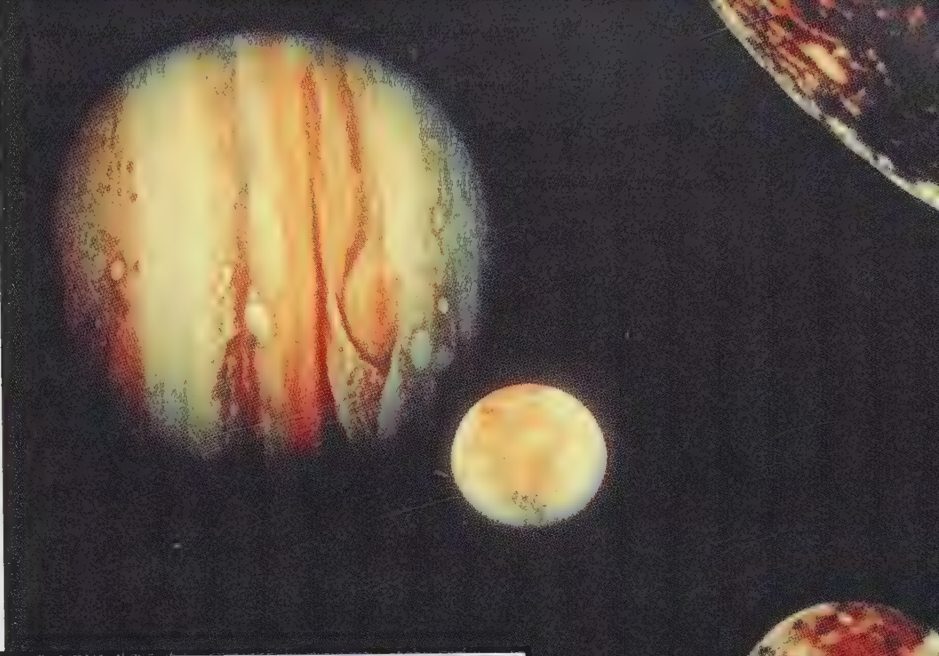


Plate 1
Jupiter and three of its "Galilean" are captured in this NASA photo montage.

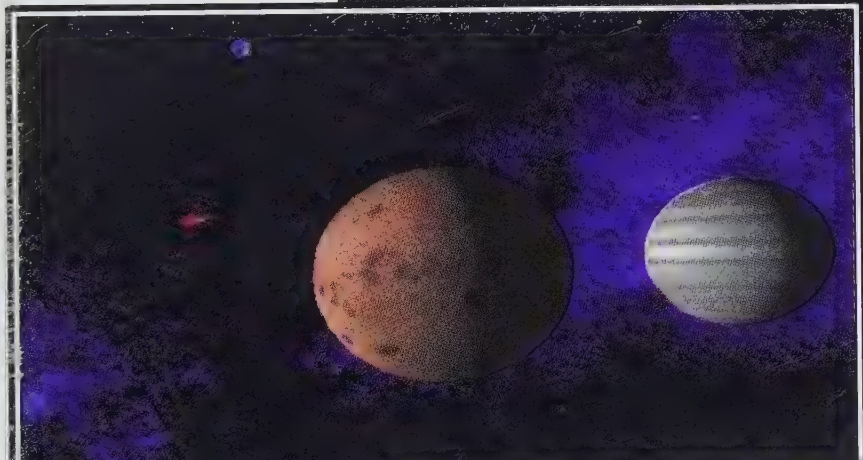


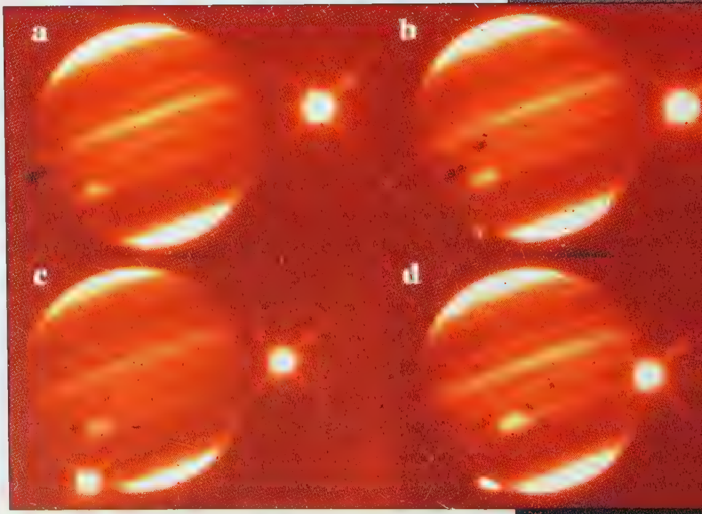
Plate 2
A spectacular view of the fictional planet Altair IV (*right*) as it is about to pass behind its seventh moon *(left*).

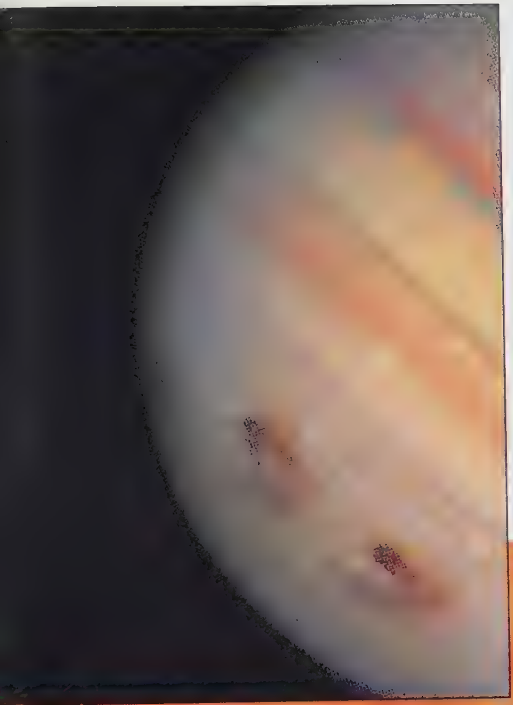
Plate 3
Space Simulator opens with this view of *Ring Station One* and Earth, with the Milky Way galaxy stretched across as a brilliant blue backdrop.

Plate 4
Your *F-79 Galactic Fighter*, searching for rogue asteroids, orbits Jupiter.

Plate 5
Space Simulator's massive *Zander Freighter* aligns with Jupiter (far) and its moon Callisto (near).

Plate 6
An infrared time sequence showing the impact of the first of the 20-odd fragments of Comet Shoemaker-Levy 9 into Jupiter on 16 July 1994. (a) Jupiter just before the impact. The bright object to the right is the moon Io and the fainter oval in the southern hemisphere is the Great Red Spot. (b) The fireball appears just above the lower-left limb of the planet. It flares to maximum brightness within a few minutes, at which time (c) its flux surpasses that of Io. (d) Jupiter approximately 20 minutes later, when the impact zone has faded somewhat. These images were taken at the German-Spanish 3.5-meter telescope on Calar Alto in southern Spain.





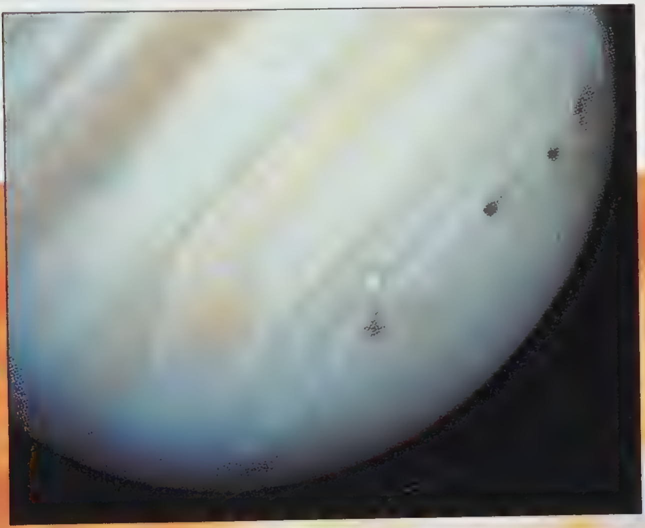


Plate 7 Top: Two images of Jupiter were taken from the Hubble Space Telescope Planetary Camera. Several impact sites are visible, the smallest being less than 200 kilometers across. These features rapidly changed over the days after the impact. Each picture is a combination of separate images taken through several color filters to create this "true color" rendition of Jupiter's multicolored clouds. The impact sites are located in Jupiter's southern hemisphere at a latitude of 44 degrees. Bottom: Jupiter before the impacts.

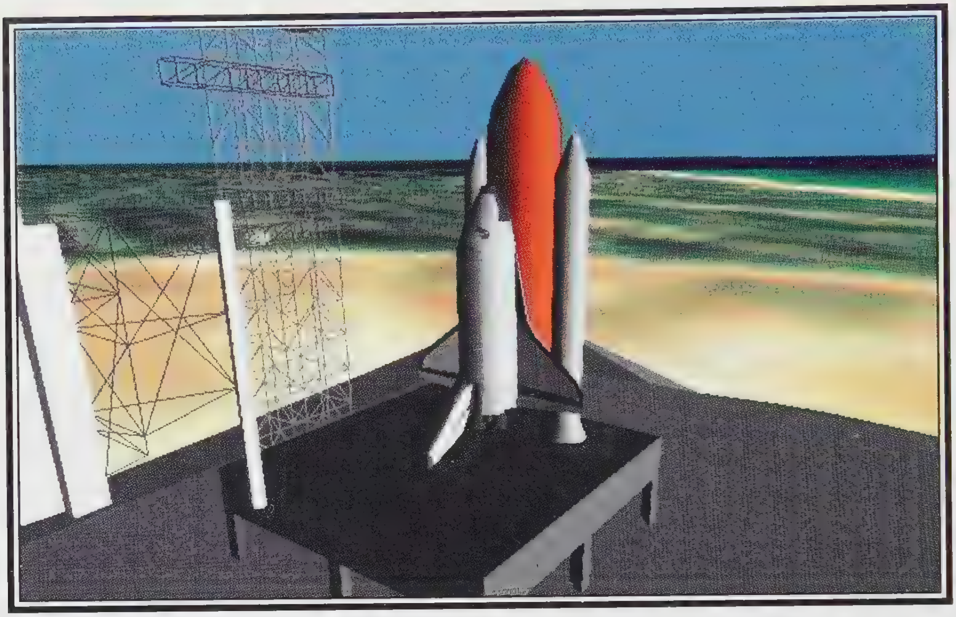


Plate 8 The U. S. Space Transportation System (STS)—better known as the space shuttle—sits on the launch pad at Cape Canaveral.

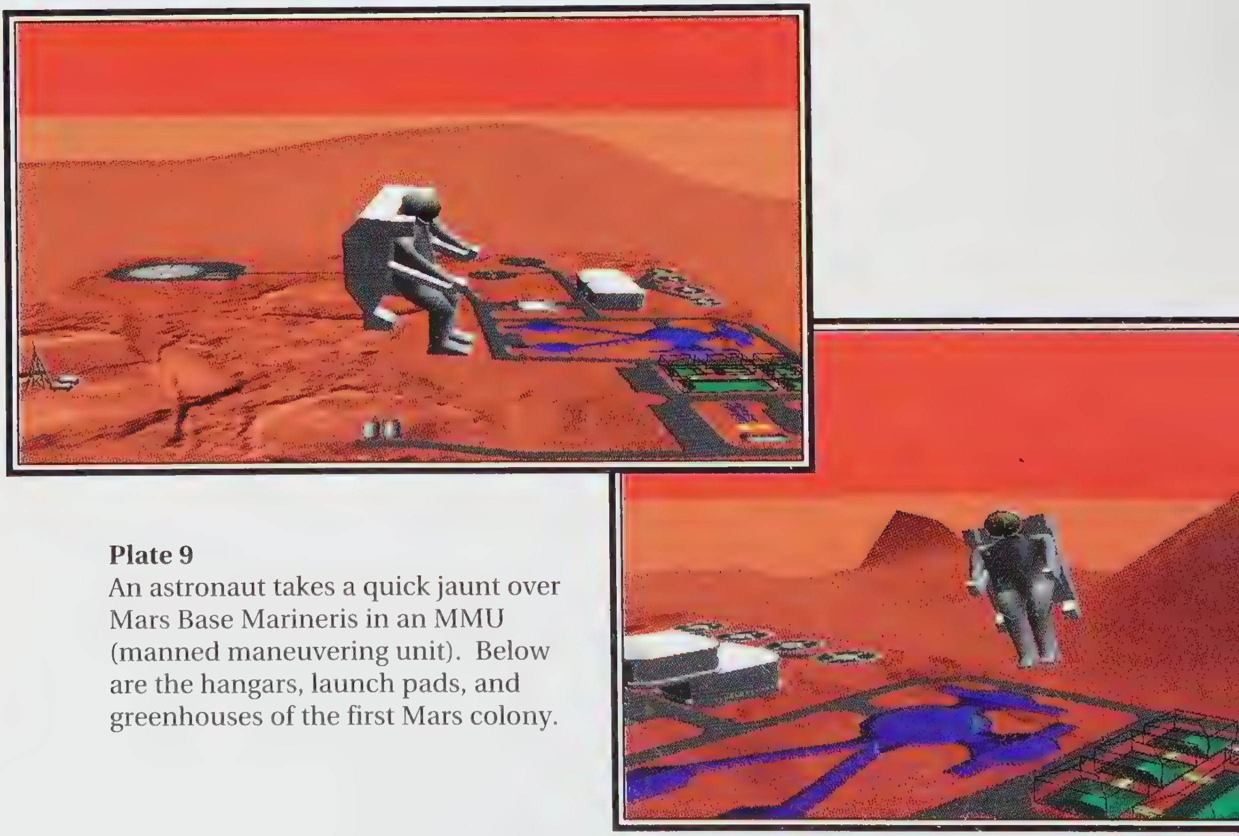


Plate 9
An astronaut takes a quick jaunt over Mars Base Marineris in an MMU (manned maneuvering unit). Below are the hangars, launch pads, and greenhouses of the first Mars colony.

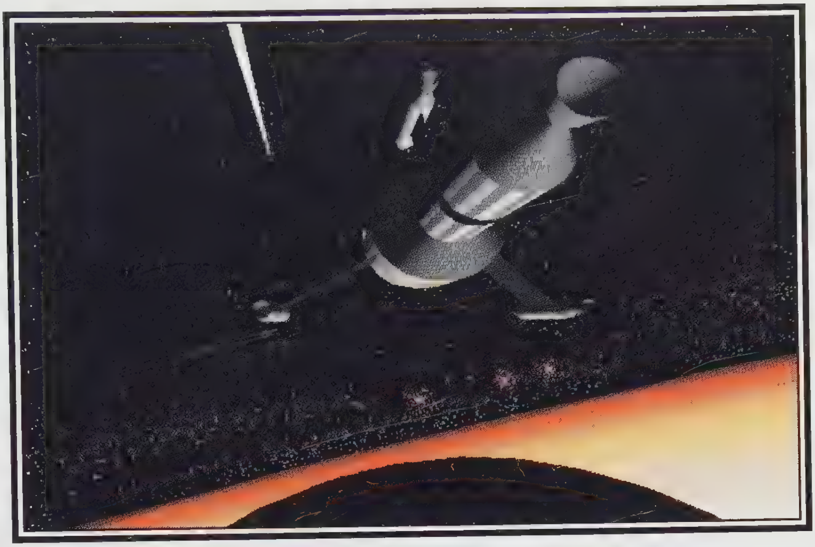


Plate 10
The *Callisto* negotiates a tricky flyover of the voracious black hole at the core of our Milky Way galaxy.

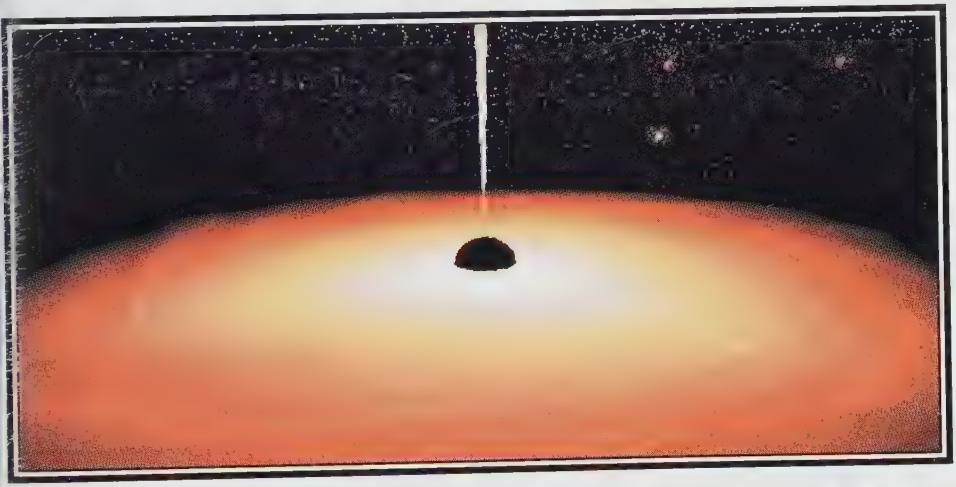
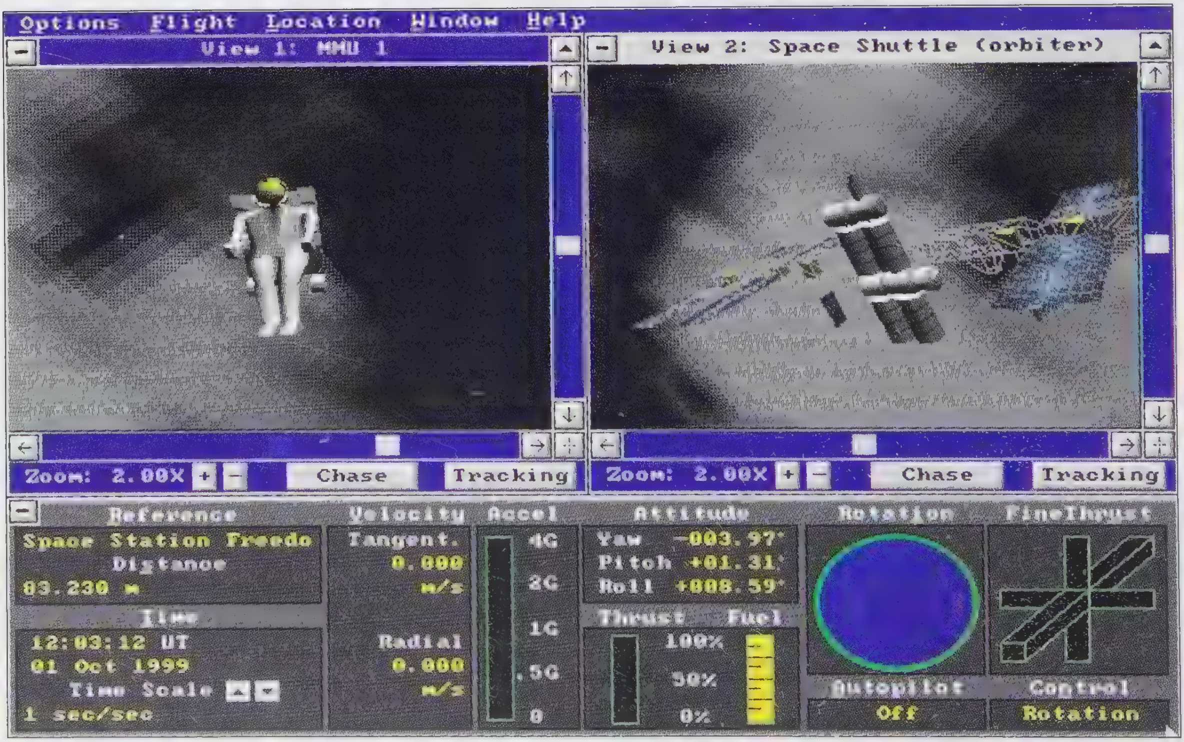


Plate 11
Here's another look at *Space Simulator*'s black hole. The spinning accretion disk of cosmic material is being sucked across an "event horizon" that marks the point of no return for all matter and energy.

Plate 12
Space Simulator lets you recreate the Apollo moon landing missions. Maneuver your LEM for a soft landing on the lunar surface.

Plate 13 A view of the Milky Way's core from high above the plane of the galaxy.


Options
Flight
Location
Window
Help
View 1: MMU 1
View 2: Space Shuttle (orbiter)
Chase
Tracking
Chase
Tracking
Reference
Velocity
Accel
Attitude
Rotation
FineThrust
4G
2G
1G
.5G
0
Thrust
Fuel
100%
50%
0%
Autopilot
Control

Zoom: 2.00X

Zoom: 2.00X

Space Station Freedo
Distance
03.230 m

Time
12:03:12 UT
01 Oct 1999
Time Scale
1 sec/sec

Tangent.
0.000
m/s

Radial
0.000
m/s

Yaw -003.97°
Pitch +01.31°
Roll +008.59°

Autopilot: Off

Control: Rotation

Plate 14 *Space Simulator*'s View Tools give multiple perspectives of this tour of *Space Station Freedom* by an MMU-clad astronaut.

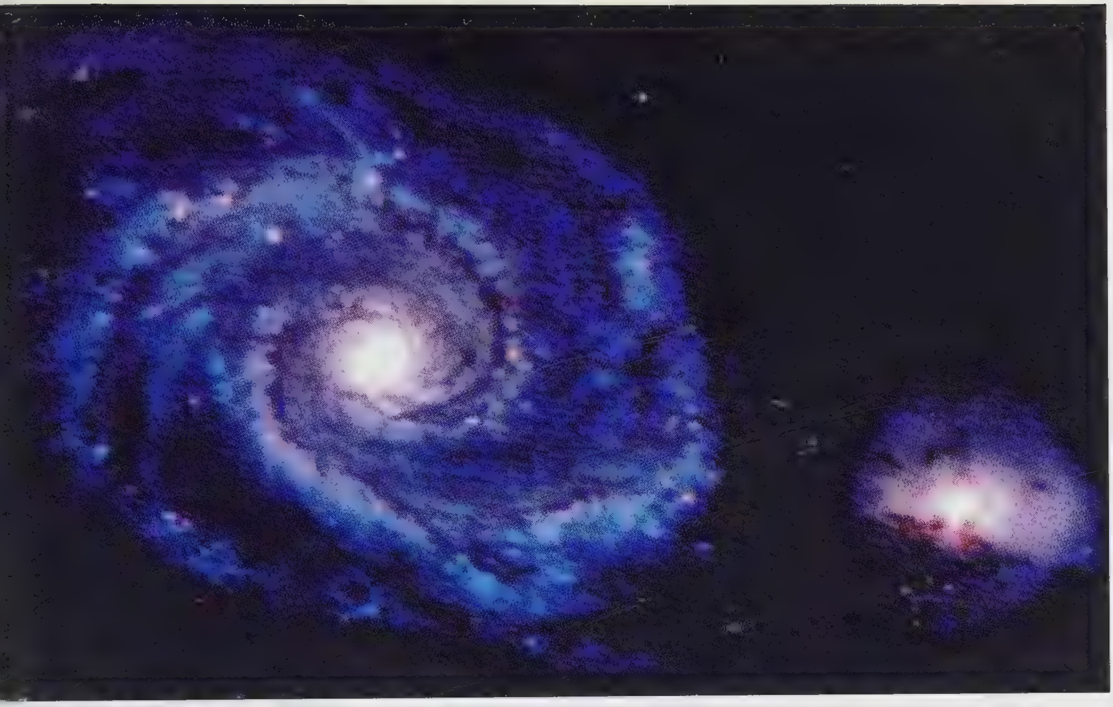


Plate 15 A panoramic full-screen view of the Whirlpool Galaxy, as seen through the telescope of the *Space Simulator* observatory.

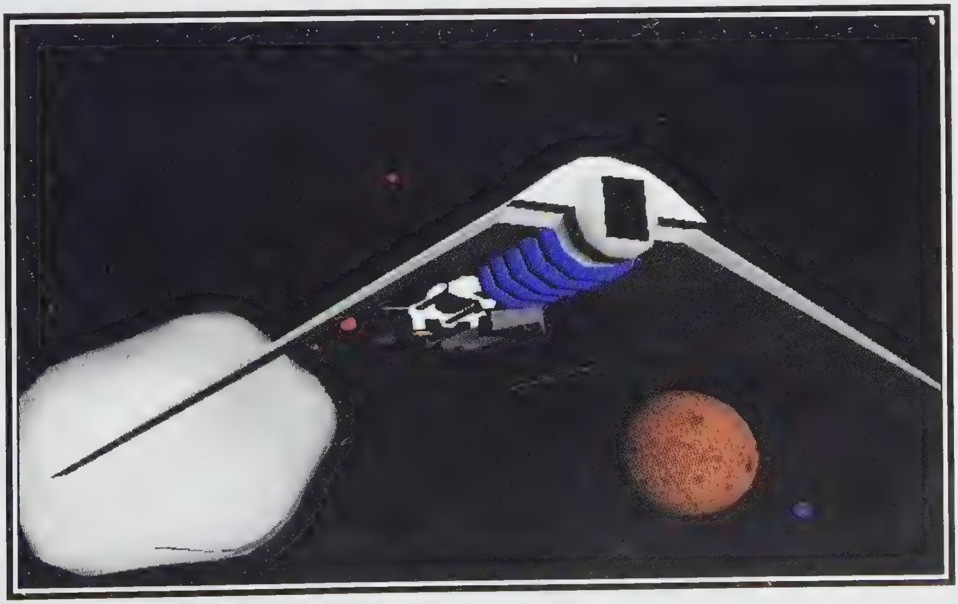


Plate 16 Your *F-79 Galactic Fighter* hovers near the irregular moon of Alpha Centauri II, the second planet of the Alpha Centauri system.

Plate 17
The space shuttle glides to a landing at Cape Canaveral in Florida.

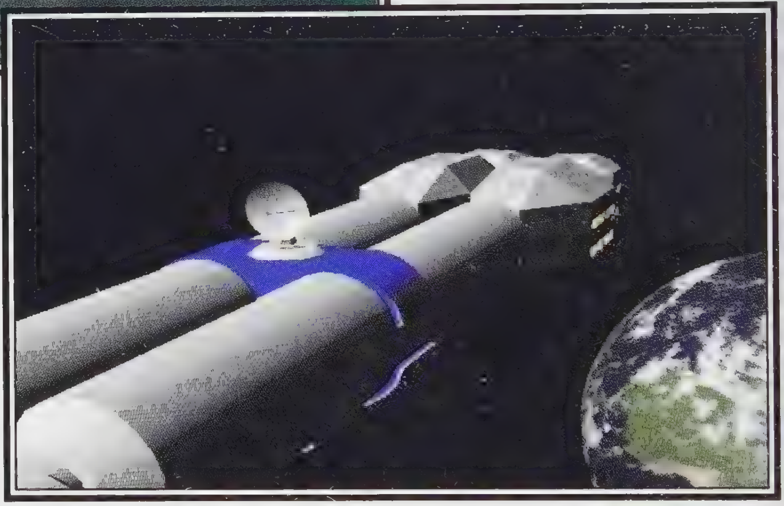


Plate 18
The *Galactic Explorer* returns to home planet Earth after another interstellar space run.

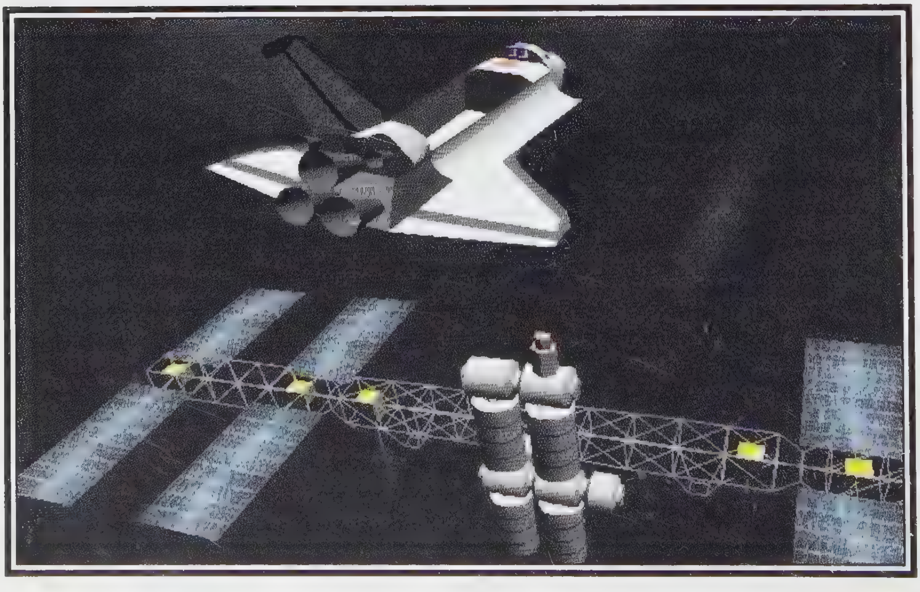


Plate 19
One existing spacecraft, the space shuttle, prepares to dock with a proposed one, *Space Station Freedom*.

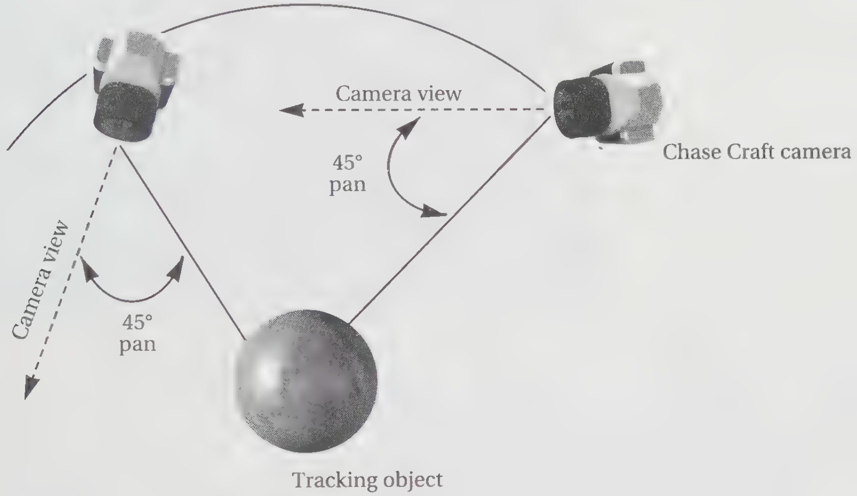
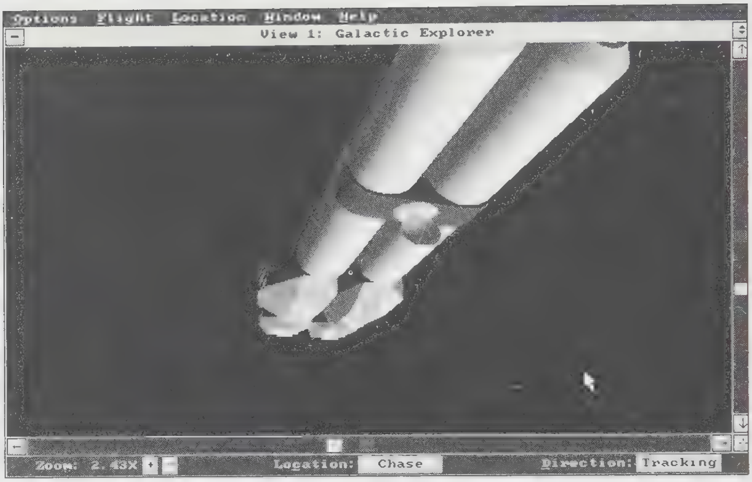


Figure 3 *How a Panning Mode Angle Adjustment Affects your Tracking Mode View*

Tracking mode. So now, even though you've returned to "swinging on a string" around the tracking object (Tracking mode) rather than "swiveling" the camera around in a fixed position (Panning mode), your camera view still maintains that 45 degree angle perspective to the tracking object. (See Figure 3.)

16. Still in Tracking mode, move the panning box slowly along the horizontal panning bar, then do the same on the vertical panning bar.

You can see that although your camera is indeed swinging around the tracking object (the ATL), it is keeping the 45-degree camera angle that you set in Panning mode—all you can see of the ship is just the tips of it.


Options Flight Location Window Help
View 1: Galactic Explorer

Zoom: 2.43X

Location: Chase

Direction: Tracking

Figure 4-5 Maximize View. *Here's a nice maximized view of your* Galactic Explorer. *Note the double arrow in the upper-right corner. Click on that (or press* !*) to bring back the instrument panel.*

Maximize View

Click the Maximize View button (or press Ctrl + F10) for a bigger window view. This button hides the instrument panel but leaves all your view tools, as well as the menu and title bars, at the top of the screen.

WINDOW MENU

The Window menu lets you configure your view windows in a number of different ways.

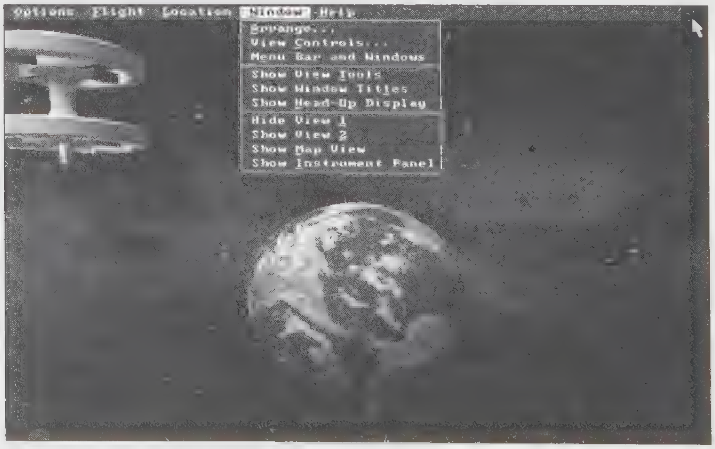

Options Flight Location Window Help
Arrange...
View Controls...
Menu Bar and Windows
Show View Tools
Show Window Titles
Show Head-Up Display
Hide View 1
Show View 2
Show Map View
Show Instrument Panel

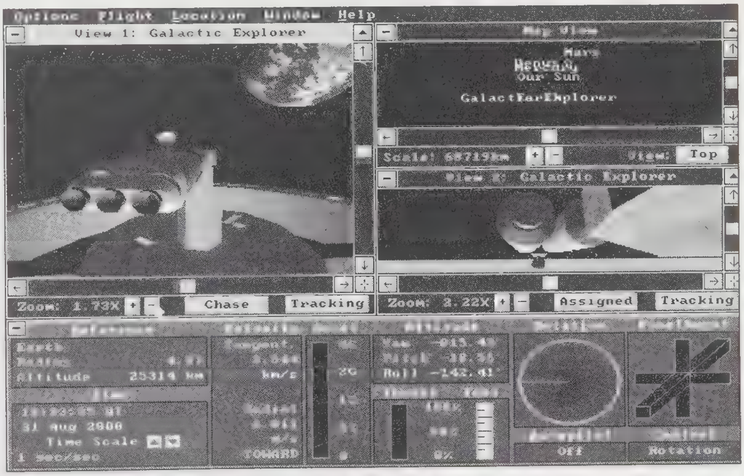
Figure 4-6 Window Menu. *This handy pull-down menu lets you create a custom view of your galactic adventures.*

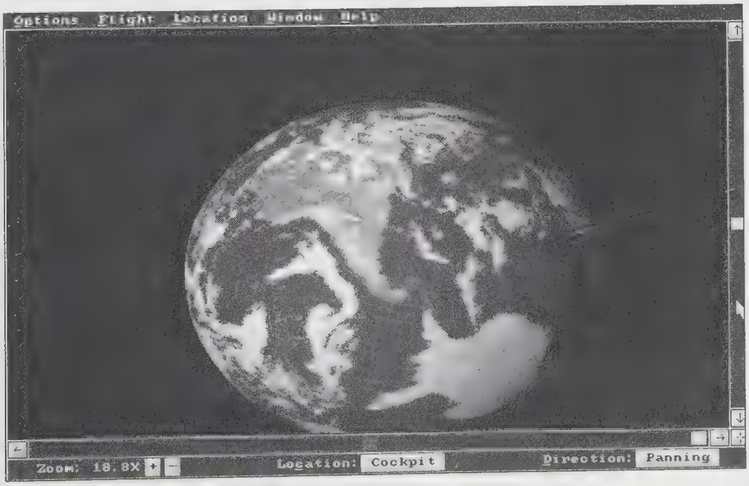
Arrange Views

Space Simulator combines the thrill of star-piloting with the splendor of celestial sightseeing. Sometimes these two benefits have different viewing needs—a delicate space docking procedure may require multiple views and full instrumentation, while a breathtaking planetary flyby calls for a panoramic, uncluttered single-window view.

The Arrange option in the Window menu lets you configure your viewing screen with as many or as few viewing options as you wish. When you click on selection boxes, the "window preview" automatically reconfigures itself to show you the arrangement you've selected.

Figure 4-7 Arrange Your Windows. *By clicking on the selection boxes, you can arrange your viewing screen. Here are a couple of examples.* Right: *You need multiple views and instrumentation to make good piloting decisions in a docking procedure with the Ring Station.* Below: *This sightseeing-oriented arrangement gives you an uncluttered vista of Earth's placid beauty, yet keeps your view tools handy.*


Options Flight Location Window Help
View 1: Galactic Explorer
Map View
Mars
Mercury
Our Sun
GalactEarExplorer
Scale: 697193km
View: Top
View 2: Galactic Explorer
Zoom: 1.73X
Chase
Tracking
Zoom: 2.22X
Assigned
Tracking
Earth
Altitude 25314 km
km/s
31 Aug 2000
Time Scale
1 sec/sec
TOWARD
Roll -142.41
Off
Rotation


Options Flight Location Window Help
Zoom: 18.8X
Location: Cockpit
Direction: Panning

View Controls

Select View Controls from the Window menu to alter the placement and/or movement of the various "virtual cameras" that show the views in your view windows. You may recall that your *Space Simulator* manual calls the View Controls option a handy "one-stop shopping" feature, because it lets you set viewing attributes for all three of your view windows.

Window View Controls

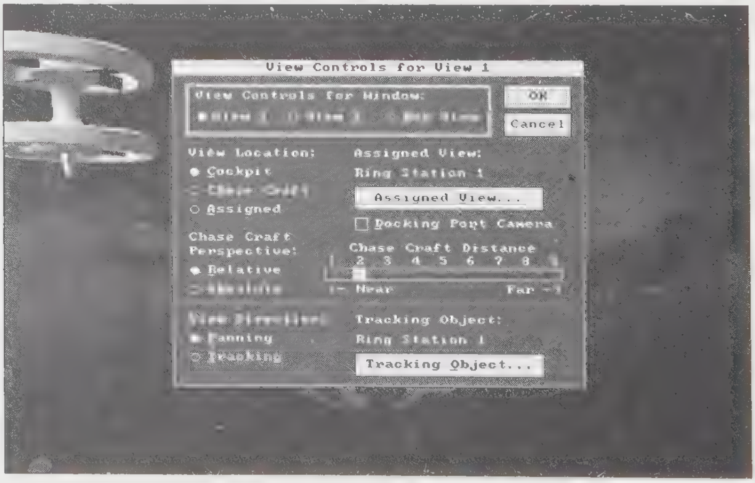
For both view windows (View 1 and View 2), you can change the assigned view or the view direction (Panning or Tracking); create new tracking objects for all three viewing locations (Cockpit, Chase, Assigned); and alter the distance and perspective of your chase craft.

Map View Controls

You can also customize the Map View. Select View Controls from the Window menu, then click on the Map View button in the "View Controls for Window" box at the top. Now you can add or remove types of objects labeled on the map, or you can change the map origin—the map's fixed central reference object.

Chase Craft Perspective

You can toggle your chase craft perspective between two settings: Relative and Absolute.



View Controls for View 1

View Controls for Window:

View Location:
● Cockpit
○ Assigned

Assigned View:
Ring Station 1

☐ Docking Port Camera

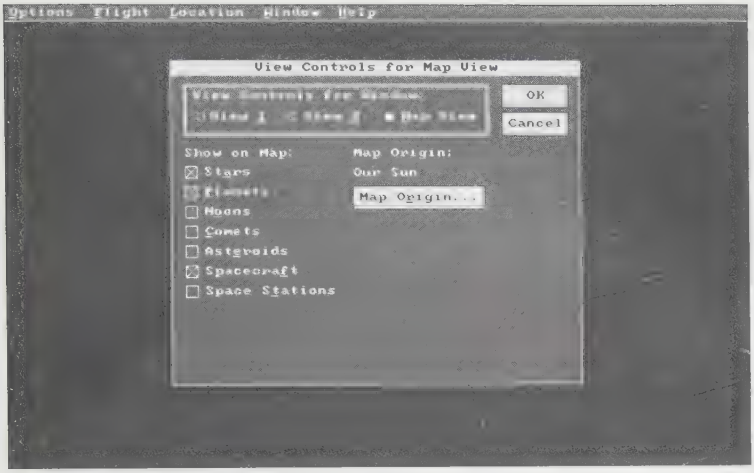
Chase Craft Perspective:
● Relative

Chase Craft Distance

Tracking Object:
Ring Station 1

● Panning

Figure 4-8 Window View Controls


Options Flight Location Window Help
View Controls for Map View
OK
Cancel
Map Origin...

Show on Map:
☒ Stars
☒ Planets
☐ Moons
☐ Comets
☐ Asteroids
☒ Spacecraft
☐ Space Stations

Map Origin:
Our Sun

Figure 4-9 Map View Controls

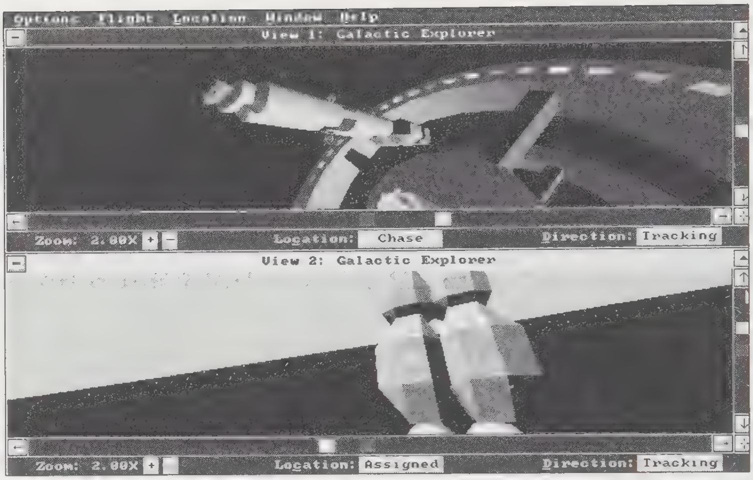
- **Relative perspective** keeps your view relative to the spacecraft you are chasing. The Chase view camera acts as if it's attached to the spacecraft, always keeping the same distance and viewing angle of the spacecraft, no matter what wild gyrations the spacecraft is performing.
- **Absolute perspective** keeps your chase camera at a fixed distance, but detaches it from the spacecraft you are chasing. Thus, if your spacecraft is yawing around in a wild spin, you will see the craft tumble against the background of space. (In Relative perspective, on the other hand, the yawing craft will appear stationary in the view window, while space rushes past.)

Assigned View Button

The Assigned View button is another route to the Select Assigned View Location dialog box discussed earlier in this chapter (see "View Location: Cockpit, Chase, Assigned").

Docking Port Camera

If you designate a space station or spacecraft as the Assigned view location, you can click on the Docking Port Camera box to place the virtual camera right in the docking port. This way you can use Assigned view with Chase or Cockpit view, giving you an extremely helpful angle during a manual docking procedure.


Options Flight Location Window Help
View 1: Galactic Explorer
View 2: Galactic Explorer

Zoom: 2.00X
Location: Chase
Direction: Tracking

Zoom: 2.00X
Location: Assigned
Direction: Tracking

Figure 4-10 Docking Port Camera. *Move your Assigned view camera right into the docking port for docking procedures. Here, the docking port camera in the Ring Station (showing you View 2 on the bottom) lets you line up your* Galactic Explorer*'s docking port, the bright orange hexagon on the bottom.*

Full Screen View

Select Full Screen View from the Window menu to enlarge your current View 1 window completely across the screen, edge to edge, in a spectacular display of galactic splendor. Note that after you activate full-screen view, the Window menu item now reads "Menu Bar and Windows." To go back to your original view, select Menu Bar and Windows from the Window menu, or just press the Esc key.

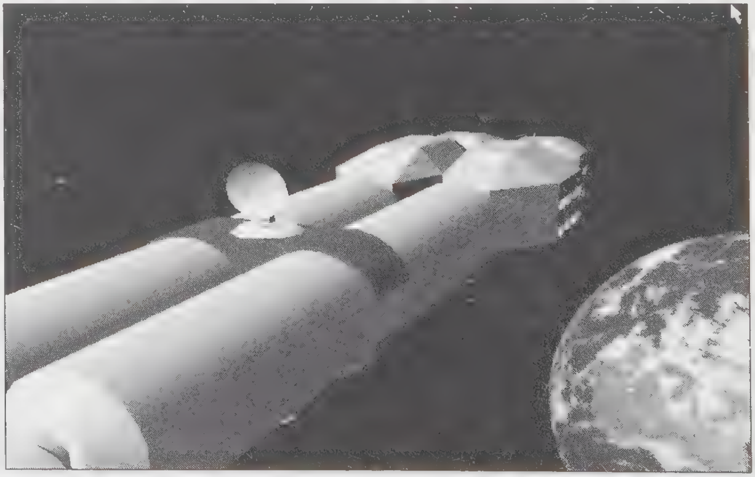


Figure 4-11 Full Screen View. *Here's where* Space Simulator *really shines. It doesn't get any better than this, does it?*

Show/Hide Other View Features

Toggle between Show [item] or Hide [item] for various other viewing features in the Window menu. If an item is currently shown, the Hide option appears in the menu; if an item is currently hidden, the Show option appears in the menu. Click on any item to automatically change its state.

- **Show/Hide View Tools** Select Hide to remove the view tools from the screen, including the panning bars, Reset button, and the Zoom, Location, and Direction buttons.
- **Show/Hide Window Titles** Select Hide to remove the title bars from the top of the view windows.
- **Show/Hide Head-Up Display** Select Show to bring up a navigation overlay for precision flying. You will read more about the Head-Up Display in Chapter 6.
- **Show/Hide View 1** Toggle View 1 on and off.
- **Show/Hide View 2** Toggle View 2 on and off.
- **Show/Hide Map View** Toggle Map View on and off.

Note: Each of the view windows—View 1, View 2, and Map View—has its own set of view tools. You can set different view locations and directions, zoom settings, panning angles, and so on, for each of them.

- **Show/Hide Instrument Panel** Toggle the instrument panel on and off. The view tools remain, however.

MAKING SPACE VIDEOS

One nifty feature of *Space Simulator* is the Video Recorder on the Options menu. All the budding Stanley Kubricks and George Lucases now have a tool to help create space movies of unparalleled cinematic brilliance.

Those of you with lesser aspirations will probably enjoy the Video Recorder feature too. And those of you who can't fathom how to put a space film together, don't despair. This section offers some basic editing tips that suggest simple, artful ways to put together some of your *Space Simulator* footage.

Video Recorder

Select Video Recorder from the Options menu to open a dialog box with all the video recording functions on it.

File Name

Type a name (up to eight letters) for your video in the File Name box.

Directory

Type the path where you want to save your video in the Directory box. (If you don't type a path, *Space Simulator* saves your video in the SPACESIM directory.)

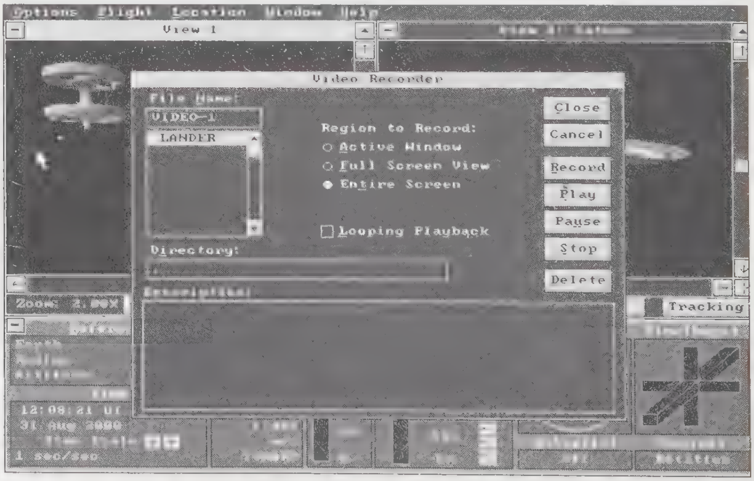
Description

If you want, you can type a fairly lengthy description of your video in the Description box.

Region to Record

Choose one of three options to designate the region of the screen you want to record.

- Select Active Window to record only what's in the active window. This is the smallest region option, so you can save hard disk space by selecting this one.


Video Recorder

File Name:
VIDEO-1
LANDER

Region to Record:
○ Active Window
○ Full Screen View
● Entire Screen

☐ Looping Playback

Directory:

Description:

Options
Flight
Location
Window
Help
View 1
Close
Cancel
Record
Play
Pause
Stop
Delete
Tracking
Zoom
12:08:21 UT
31 Aug 2000
1 sec/sec

Figure 4-12 Video Recorder. *This little dialog box could be your ticket to Hollywood—or not. In any case, the control panel bears a close resemblance to a VCR's, so you'll find it quite easy to use.*

- Select Full Screen View to record a full, borderless screen, without instrumentation, window bars, or view tools.
- Select Entire Screen to record everything on your current screen. This option is probably the best one for creating in-depth space travelogues because it lets you change your window arrangement during recording.

Looping Playback

If you have a disk-caching program such as MS-DOS® SMARTDrive, you can click on the Looping Playback box to get a smoother playback of your video. However, if the size of your recording file is larger than your disk cache, you'll lose some of the smoothness.

Record

Once you've navigated to a situation that you'd like to capture for posterity, simply click on the Record button on the Video Recorder dialog box, or better yet, simply press R. Keystroke commands work much quicker when you're recording.

By the way: If you have a slower machine, you'll notice a considerable "jerky-vision" slowdown in the picture as the program records frame by frame. Your flight controls will probably get very unresponsive as well. Don't worry, though. The playback will be much smoother. (At least it was on my machine.)

Note that the number of frames recorded and the size of the file are displayed in the upper-left corner of the screen. Keep your eye on this information. Recordings gobble quite a bit of bytes—witness the example in the "Making a Space Video" sidebar in this section.

Play

To play back a video you've recorded, select Video Recorder from the Options menu and click on the video you want in the File Name box to highlight it. If you want to *loop* the video—that is, start over once it finishes playing—click on the Looping Playback box. Then click on the Play button, or press P.

Note: If you loop the playback, you'll have to stop it yourself by pressing \ (backslash). If you don't loop the playback, it will automatically return you to spaceflight when it's over.

Pause

Press U to pause your recording. Press U again to continue recording.

Stop

Press \ to stop recording or playing your video.

Delete

To delete a video you've recorded, select Video Recorder from the Options menu and click on the video you want to delete in the File Name box and highlight it. Click on the Delete button, then click OK when queried.

Video Quick Keys

Let me repeat here that your recording sessions will go much smoother if you use keystroke commands rather than clicking away at the Options menu with the mouse. For quick reference, here they are again:

Command	Keystroke
Record	R
Play	P
Pause	U
Stop	\

Editing Tips

In one sense, cutting a video sequence is easy. "Action dictates itself," says Tom Rolf, a veteran Hollywood editor with a long list of action-oriented films to his credit, including *The Right Stuff* (for which he won an Academy Award). "A guy shoots a gun, it's going to go somewhere, and you have to show where that is."

In the kind of sequences that you'll create in *Space Simulator*, uncomplicated cuts always tell the story most effectively. In general, the less cluttered you can make the sequence, the better.

Continuity

Filmmakers should always be concerned with the *continuity* of a sequence, which simply refers to matching up the physical details in a series of related shots. In general, you want to be sure there are no discrepancies from shot to shot.

On the other hand, good editors ignore minor continuity glitches if the primary action in a scene is compelling. In fact, Tom Rolf advises that you shouldn't get too obsessed with matching frame-by-frame details. If the action's hot, the audience will be moved along by the cumulative effect and won't really notice the details. "It's amazing what you can get by with," says Rolf.

Establishing Shots

As a general rule, any short film like the ones you'll make in *Space Simulator* should quickly establish (1) an overview of the locale and (2) the precise physical relationship between the players (MMU-clad astronaut, spacecraft, and planets, for example) in that locale. In other words, visually answer the questions "What is this place?" and "Where are the major players located?"

In this way you quickly orient viewers, giving them the lay of the land for the shots that follow. These *establishing shots* create a "topography"—a physical context for viewers, who can now connect the details that follow into a coherent scheme.

Cross-cutting

Film's ability to take the action of a story instantaneously from one place to another has always been one of its main sources of appeal. The most basic way to create a compelling sequence is the device of *cross-cutting*. First introduced to film art by the great producer and director, D. W. Griffith, this fundamental technique of editing lets the filmmaker intercut between shots of two or more protagonists to suggest their physical relationship on the screen.

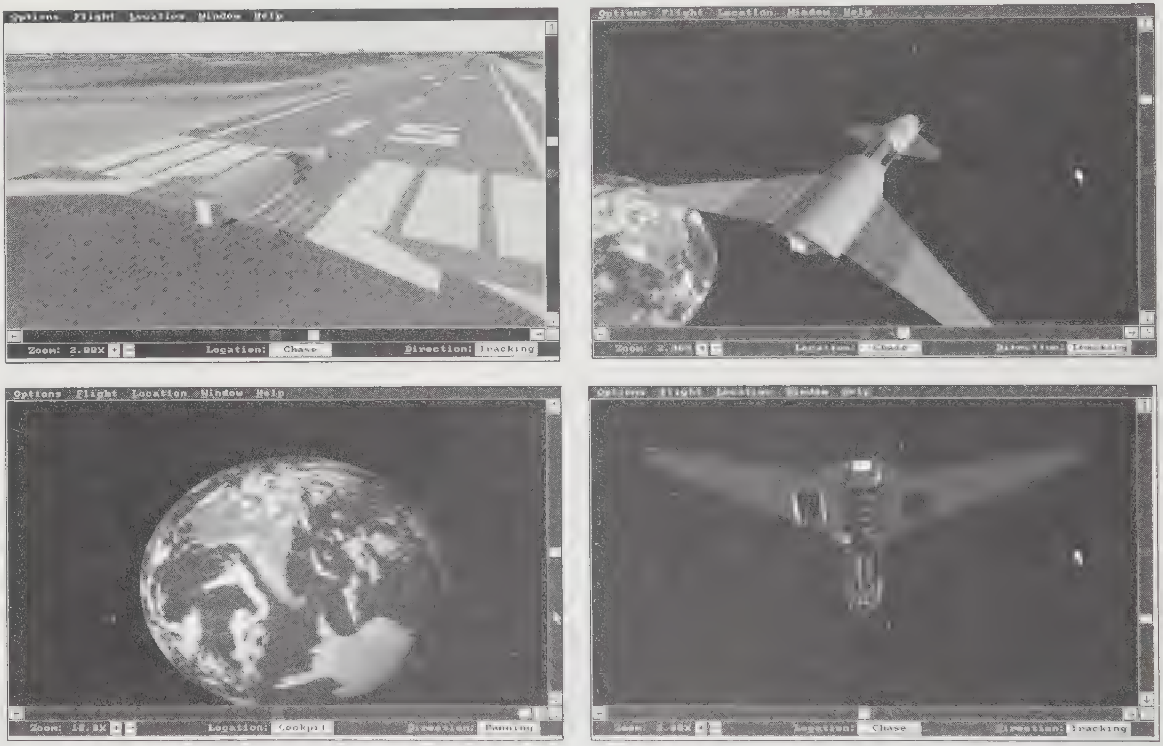
Cross-cutting creates an editing challenge, however. Rule number one of editing is always: Don't confuse the audience. If cross-cutting disorients the viewer about the physical details of the scene, you have defeated your purpose as a filmmaker.

Preserve a Sense of Direction

When editing a sequence, it's absolutely critical that you choose shots that keep the actions of players flowing in logical directions across the screen. Think of your audience as sitting on one side of a two-dimensional plane of action that intersects the protagonists in a scene. The simplest example: A *Zander Freighter* and Halley's Comet are speeding to a head-on collision.

Making a Space Video

Just for fun, I made a quick space video to test *Space Simulator*'s dramatic capacity and its hunger for hard drive space. Using a preset situation that begins with an *F-79 Galactic Fighter* on the runway at Cape Canaveral, I blasted off into orbit around the Earth, and then took some beauty shots of the spacecraft.



Zoom: 2.99X Location: Chase Direction: Tracking

Location: Chase Direction: Tracking

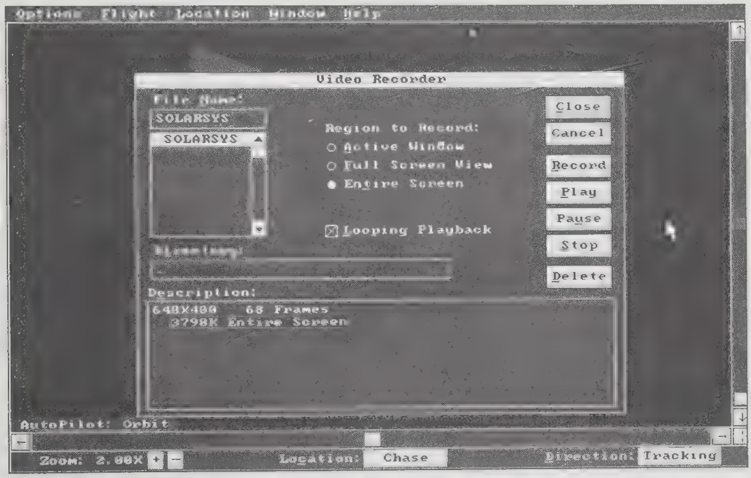
Location: Cockpit Direction: Panning

Location: Chase Direction: Tracking

Figure 1 My "Solarsys" Video, Part I. *From the Cape to a spectacular polar orbit, all captured in fifteen seconds of smooth, well-paced video (if I do say so myself).*

The comet rockets left-to-right across the screen, the *Zander Freighter* rockets right-to-left. If you violate this directional continuity—say, by inserting a shot from a reverse angle (the other side of the action), suddenly showing the *Zander Freighter* zooming left-to-right—the audience will immediately assume that it has spun around and is now wisely fleeing. If the head-on

As you can see in the screen shot of the Video Recorder dialog box shown in the next figure, I recorded 68 frames (640 by 400 display resolution) using the Entire Screen region and Looping Playback. The result: a very nice, colorful little fifteen-second show that gobbled up about 3.8 megabytes of my hard drive.



File Name: SOLARSYS

SOLARSYS

Region to Record:
○ Active Window
○ Full Screen View
● Entire Screen

☒ Looping Playback

Description:
640X400 68 Frames
3798K Entire Screen

AutoPilot: Orbit

Zoom: 2.00X

Location: Chase

Direction: Tracking

Figure 2 My "Solarsys" Video, Part II. *About fifteen seconds of video recording ate up almost 3.8 megs of my hard drive!*

The moral of the story is this: If you're a gigabyte storage kind of guy or gal, then maybe you can build some multilayered space drama with *Space Simulator*'s Video Recorder. Otherwise, be content with short cuts and snapshots.

collision then occurs, you've got a very confused audience.

Of course, you can vary the angle and distance of the shots, or even cut to head-on or *tracking* (following from behind) shots. But unless you're deliberately trying to mess with the minds of your audience, you won't want to use shots that swing around behind the plane of action.

Pace and Dramatic Tension

Good editors like to vary the pace of the cutting in order to manipulate the dramatic tension. By simply cutting an entire sequence at great speed, you can easily create a superficial impression of fast, exciting action. However, you can also create urgency and build up tension by starting slow, then gradually accelerating the rate of cutting.

Close vs. Long Shots

By varying the distance of view you can not only create visual variety, but also an illusion of continuous movement. Close shots of a film subject should be left on the screen for a much briefer interval than long shots. A close shot, where the image remains fairly still within the frame, conveys all it has to say in a short time. A long shot, on the other hand—especially one where there's movement across the frame—is a source of more sustained interest; there will generally be more components to "see" in the frame.

MISSION: WINDOWS TO THE SOLAR SYSTEM

Finally, it's time to explore the *Space Simulator* universe. You are about to fly a simple patrol mission. As captain of the *Galactic Explorer*, your job is to run a

Figure 4-13 Mission Launch. *You start your mission in this familiar place—orbiting the Earth next to Ring Station 1.*

regular scan of the Solar System, seeking planetary data for regular scientific updates on our siblings orbiting the Sun.

This mission is a lengthy one—each scanning run takes many weeks to complete. Fortunately, your time scale accelerator will let you complete the task in less than an hour, leaving time for playback of the spectacular video you will make of your adventures in the Solar System.

To get started, boot up *Space Simulator*. If your startup situation is no longer FLIGHT (looking out at Ring Station 1 and Earth from the cockpit of the *Galactic Explorer*), click on the Options menu and select Open Situation. Choose the situation called FLIGHT in the File list, then click on OK.

Make a Video of Your Mission

Part of your general assignment as a fleet captain is to keep a video log of your missions. You'll shoot a few frames of everything interesting that you see along the way. To get your video log rolling, do the following:

1. Select the Video Recorder option from the Options menu.
2. Click on the File Name box, delete whatever is there, then type in SOLARSYS.
3. If you want, you can click on the Description box and write a brief memo about the mission you plan to log.
4. Click on the Entire Screen button under Region to Record. (This lets you change your window configurations without having to start a new video recording each time.)
5. Click on the Looping Playback box.
6. Now click on the Record button and shoot a few frames of your starting point at Ring Station 1.
7. When you've shot ten frames or so, press U to pause the recording.
8. Whenever you see anything you'd like to record during the mission, simply press U to "unpause" the recording, shoot a few frames, and then press U again to pause the recording.

Unless you're blessed with massive hard drive space, I'd recommend shooting only ten to twenty frames of video at each location that looks interesting. Remember the general rule: Hold longer on wide-angle shots or dynamic (moving) shots; hold shorter on close-up or static shots.

Mission Launch

OK, you're ready for some sightseeing. For the simple purposes of this flight, I suggest you set your skill level to Practice (under Options/Preferences). This way you don't have to worry about refueling, crashing, and other problems. Then do the following:

1. Select Autopilot from the Flight menu.
2. Use the Destination button to change your current destination to Mercury. (Be sure to update your Reference Object by clicking on the box.)
3. Under Action, select Orbit. Then click on Execute.

You are now on your way to an orbital engagement with Mercury, the speediest planet in the Solar System. Your remarkable ability to accelerate at a steady rate of 4 g's, combined with *Space Simulator*'s automatic time scale management, puts you in slightly elliptical orbit around the closest planet to the Sun in a few minutes.

Mercury

Let's be honest. Mercury is not a happy planet. Imagine the Sahara Desert having a really bad day. The Sun, which is only 36 million miles away from Mercury, looms nine times larger than in our own sky. With a diameter of just 3,000 miles, Mercury is about two-fifths the size of Earth, with only 5.5 percent the mass. As a result, Mercury's lesser gravity is unable to hold an atmosphere. (Most atmosphere-forming gases, being very light, just drift away from weak-gravity planets.)

As you orbit Mercury, you'll notice how its battered surface resembles that of our Moon. Thousands of huge craters pockmark the planet, which is quite dead; Mercury's late-afternoon temperature reaches an ovenlike 400 degrees Fahrenheit. "Late afternoon," by the way, is a pretty misleading term. Each Mercury day is about two Earth *months* long.

Watching Your Orbit

The Orbit option on the Autopilot's Action list is a handy, fun little feature. Let's take a closer look at Mercury, and at yourself, as well. Here's how:

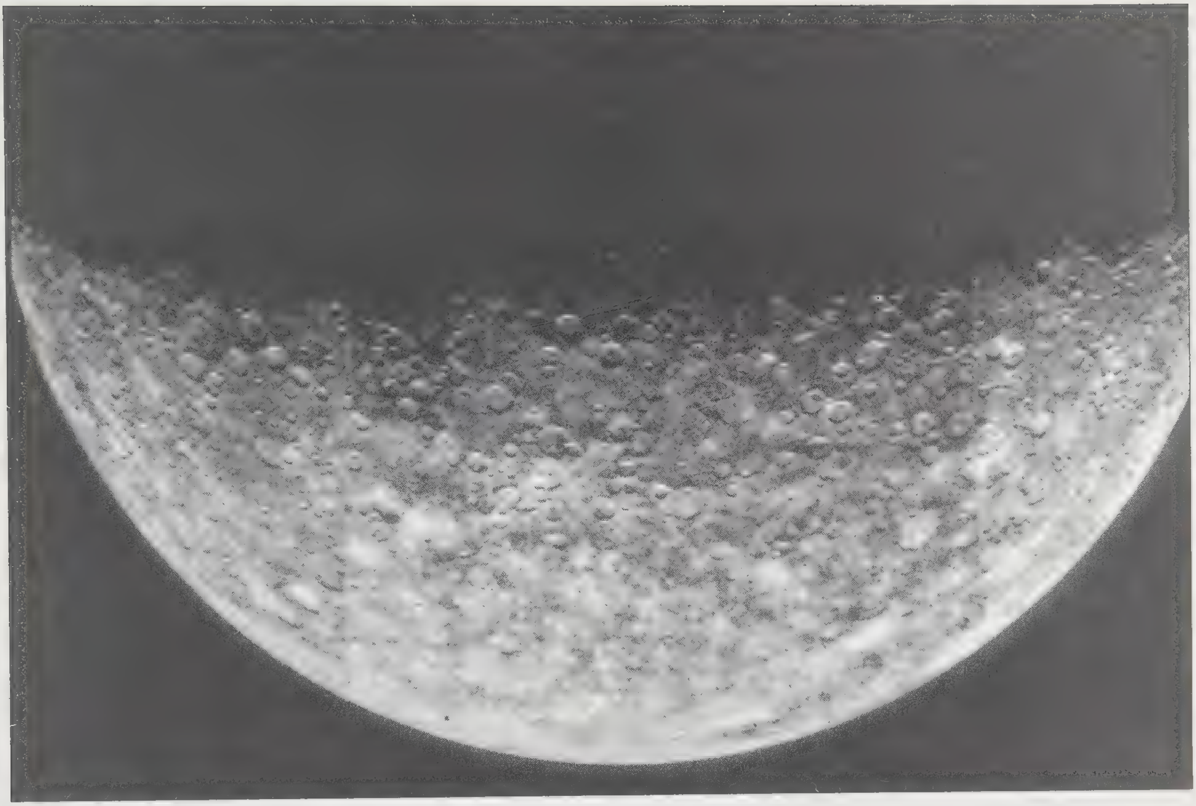
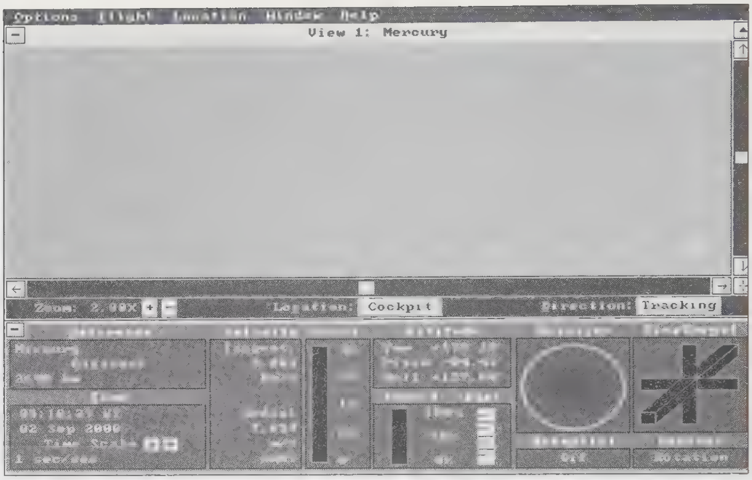


***Figure 4-14* Mercury.** *Here's the closest planet to the Sun, as seen by* Mariner 10 *in 1974. It almost makes the Moon look cheery.*

1. Choose View Controls from the Window menu. Select the View 1 and Cockpit buttons, if they aren't already selected. (They should be.)
2. Click the Tracking Object button at the bottom of the dialog box, then choose Object Type: Planets and select Mercury. Click on OK.
3. Toggle the Direction button from Panning to Tracking.

Wow. There it is—Mercury—way bigger than life. You've now set Mercury as the new tracking object from Cockpit view, so you'll have the planet centered in View 1 regardless of your spacecraft's orientation.

Since you're only 200 kilometers above the surface at this point, the view's kind of overwhelming. You can click the Zoom Out button a few times for a better view, if you want. But I'll show you how to expand your orbit in a moment, giving a somewhat less in-your-face view.


Options Flight Location Window Help
View 1: Mercury

Zoom: 2.00X

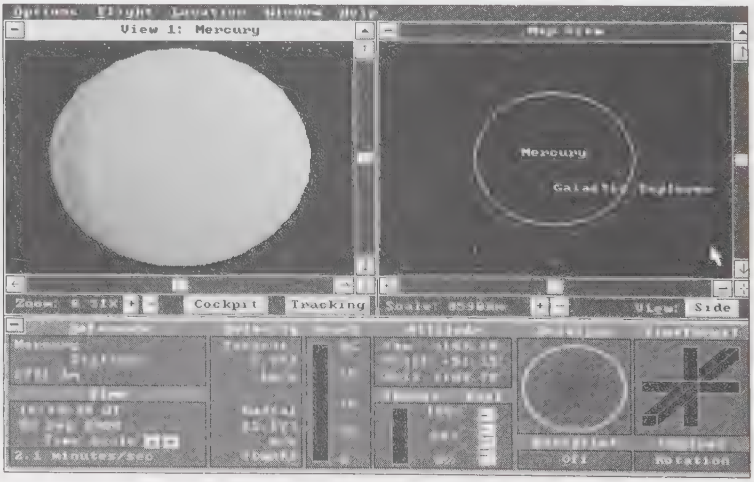
Location: Cockpit

Direction: Tracking

Figure 4-15 Tracking Object Mercury. *Here's the view from 200 kilometers above Mercury's surface, tracking the planet in Cockpit view. Not much to see from this distance.*

In the meantime, let's play with Map View:

4. Select Arrange from the Window menu, click on the Map View box, then click OK.
5. Now select View Controls from the Window menu. Click on the Map View button.
6. Change Map Origin to Mercury and click OK. When you get back to the View Controls dialog box, click OK again.
7. On the Map View window, click the Scale button until you zoom in to 8590km, then click the View button twice to change the view to Side.


Options Flight Location Window Help
View 1: Mercury
Map View
Mercury
Galactic Explorer

Zoom: 0.51X

Cockpit

Tracking

Scale: 8590km

View: Side

Figure 4-16 Map View of Mercury Orbit. *Watch the* Galactic Explorer *ring around Mercury in the Map View at right. In this shot, I zoomed View 1 (left, tracking Mercury) out a bit (0.51X) to show the whole planet.*

8. Now speed up the Time Scale setting to 2.1 minutes/sec.

Neat little Map View, isn't it? As the map labels indicate, that big yellow circle on the map is Mercury, and the little blue dot going around it is your *Galactic Explorer.*

Note: Since your orbit is very slightly elliptical, you can also watch the orbital mechanics at work on the velocity and distance readouts of your instrument panel. Notice how the radial velocity decreases after you swing past the *perigee* (nearest point) of your orbit, then increases as you circle past your point of apogee.

Now let's open up both your orbital radius and the Map View a bit:

9. Open the Autopilot dialog box again and select Orbit. Important: Make sure Current Destination is set to Mercury.
10. Click on the Orbital Radius button. When the new dialog box appears, click on the Altitude above Surface button.
11. Click on the Radii button. Delete the figure in the Altitude box and type 2 in the box. Click on OK. Your Orbital Altitude should now be listed as "2 radii."
12. Click on Execute.
13. On the Map View window, click the Zoom Out button once to reduce the zoom scale to 17180km.

Now watch your *Galactic Explorer* slowly climb to a higher orbit of about 4,880 kilometers above Mercury's surface.

Reminder: Here's a good place to shoot some video. Just press U to unpause your recording, let ten or twenty frames roll, then press U to pause the recording again.

My gut feeling here is that you've seen all of Mercury you'll ever want to see. Not a real exciting place, Mercury. At least you got to put your Map View to use.

Let's move on to Venus, shall we?

Venus

Venus, the second planet from the Sun, is often called our sister or twin planet. There are several reasons for this. Venus is Earth's closest planetary neighbor,

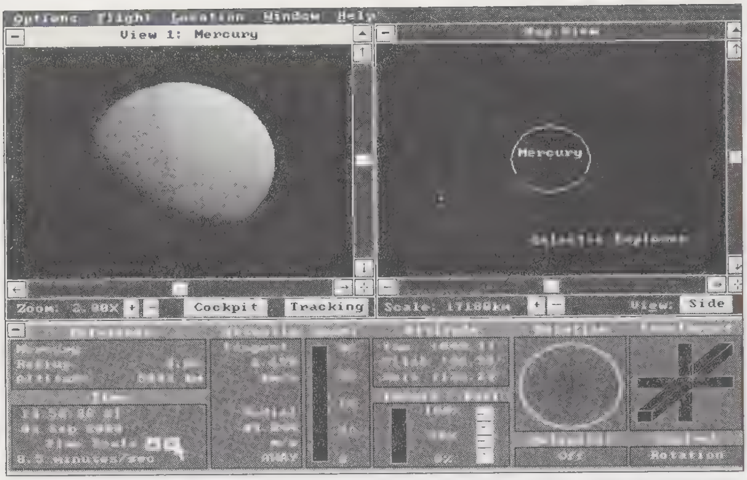
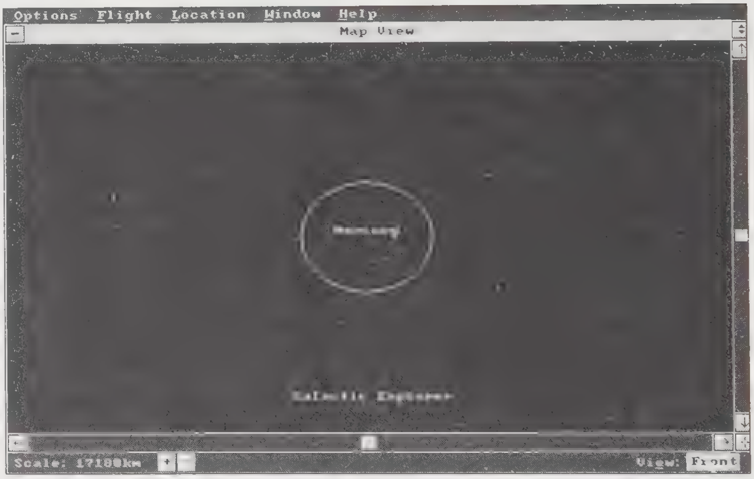

Options Flight Location Window Help
View 1: Mercury
Map View
Mercury
Galactic Explorer
Zoom: 2.00X
Cockpit
Tracking
Scale: 17180km
View: Side
Off
Rotation

Figure 4-17 Higher Orbit.
Above: *The tracking shot of Mercury recedes in the View 1 window as you climb higher into a 2-radii orbit of the planet.* Right: *Click the Maximize button on the Map View window, then click the View button to switch to a front view of your orbit. When you're done watching, minimize the view again to bring back the instrument panel—i.e., click the double-arrow button in the upper-right corner.*


Options Flight Location Window Help
Map View
Mercury
Galactic Explorer
Scale: 17180km
View: Front

and it has very nearly the same size, mass, and chemical composition. It also has a dense atmosphere, full of clouds. Unfortunately, the Venusian atmosphere is almost pure carbon dioxide, and the clouds consist mostly of sulfuric acid. So if Venus is our twin, it is a somewhat evil twin.

Let's visit anyway. Your scanning mission calls for a simple orbital pass, so don't worry about corrosive clouds, or the howling 200 MPH winds, or the sizzling 900-degree temperatures (hot enough to melt lead), or the crushing atmospheric pressure on the surface. No, just keep your distance and take some pretty pictures.

First, alter some view features so that you can watch Venus coming, rather than watch Mercury going:

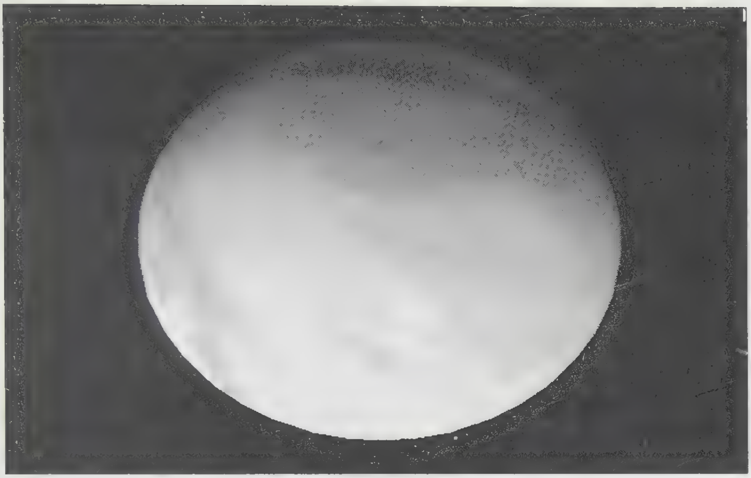


Figure 4-18 Venus. *Some call it the "planet of love." But at 900 degrees Fahrenheit, it's more like hell.*

1. Select View Controls from the Window menu. Be sure the View 1 and View Location: Cockpit buttons are selected, then change Tracking Object to Venus. Click the Select Tracking Object dialog.
2. Click the Map View button, then change Map Origin to Venus. Click on the Map Origin and View Controls dialogs.
3. On the Map View window, click the Zoom Out button eight times, until the zoom scale reads 4.4 mkm (million kilometers).

Now you can watch the *Galactic Explorer* approach Venus on the Map View. Let's disengage from our Mercury orbit now and head for the "planet of love":

4. Choose Autopilot from the Flight menu and change your Current Destination to Venus. Be sure to click on both the Reference Object and Tracking Object boxes to update them.
5. Select Orbit from the Action list.
6. The orbital radius is set at 7,317 kilometers, the distance of your Mercury orbit. Change the orbital radius to 2 radii for the Venus orbit, as you did for the Mercury orbit, but this time click the Distance from Center button. Click OK.
7. Click on Execute.

You're on your way to Venus. Watch the Map View window first; you'll see the *Galactic Explorer* appear on the map from the left. As the ship draws closer

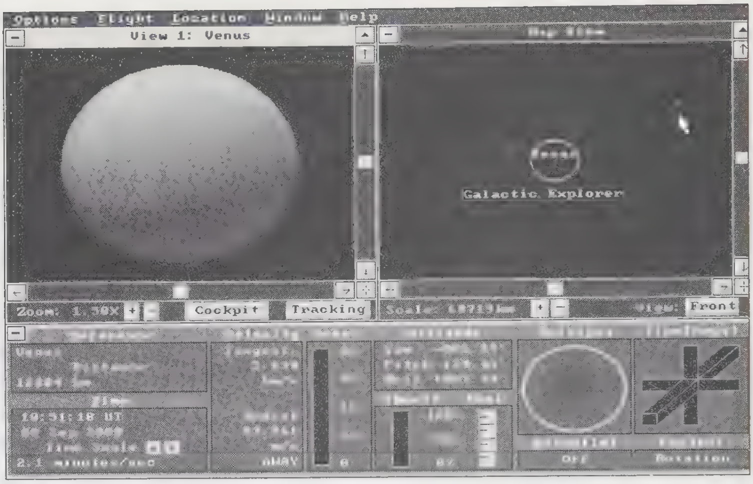


Figure 4-19 Venus Approach. *As your ship begins its loop around Venus, you might want to lower the Zoom setting in your View 1 window to 1.50X for a fuller view of the planet.*

to its destination, pause the simulation and click the Zoom In button on the Map View to bring it up to a scale of 68,719 km.

Now sit back and enjoy the approach to Venus in your View 1 window.

Reminder: Here's another good place to shoot some video. Just press U to unpause your recording, let ten or twenty frames roll, then press U to pause the recording again.

Panning Around Your Starship

During the Venus approach, you hear a disturbing thump from the front hull of your ship. A meteoroid, perhaps? Fortunately, none of your navigation or life-support systems seem affected. But you didn't get to be fleet captain by ignoring this sort of thing. Time for a look.

In the old days, you'd suit up for a quick EVA inspection. But now you simply manipulate your remarkable Chase view robotic camera. Here's how:

8. Choose Arrange from your Window menu, click on the View 2 box, then click off the Map View box. Click OK.
9. Now choose View Controls from the Window menu and click on the View 2 button.
10. Select Chase Craft, then change Tracking Object to your current spacecraft, the *Galactic Explorer.*
11. Move the chase craft camera nearer to your spacecraft by clicking on the Chase Craft Distance bar under the number 2. Click OK.

Now you have a rear view of the *Galactic Explorer* in the View 2 window. Play with the horizontal and vertical panning bars until you find a view that's sufficiently cool—preferably with Venus framing the ship in the background. (If you're on the planet's dark side, you can hurry to the sunny side by speeding up the Time Scale setting to about 2.1 minutes/second—but only after the Autopilot disengages, since Time Scale cannot be manipulated during Autopilot sequences.) Then pause the simulation.

Let's get the full effect of the view:

12. Open the Window menu and select Hide View Tools.
13. Now click on the Maximize button up in the right corner of the View 2: Galactic Explorer window. You might end up with something like this:

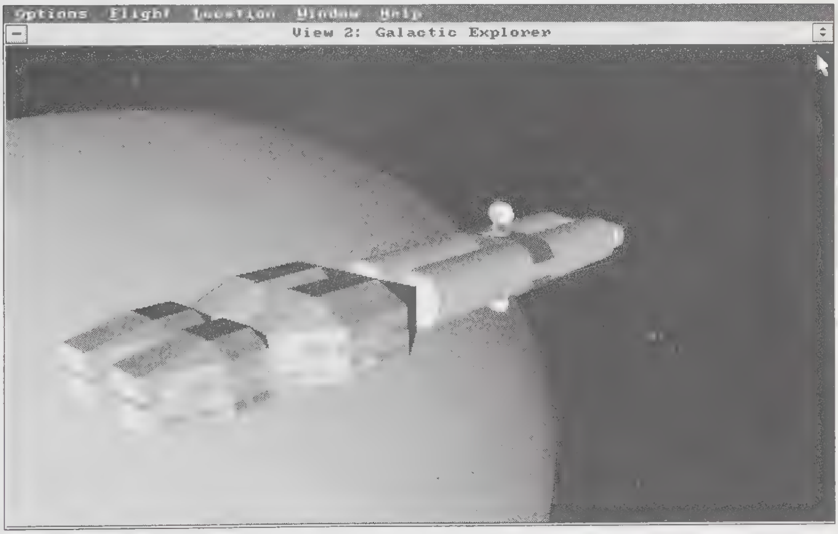


Figure 4-20 Ship Inspection. *There's nothing like a 360-degree spin around the old space buggy. Venus looks pretty nice in the background, especially in this maximized view with the view tools hidden.*

Reminder: Here's another good place to shoot some video. Just press U to unpause your recording, let ten or twenty frames roll, then press U to pause the recording again.

14. Open the Window menu and select Show View Tools. Now pan around in your maximized view for a while. Remember, you want to inspect the front hull of the *Galactic Explorer* for meteoroid damage. Zoom in as close as you can.

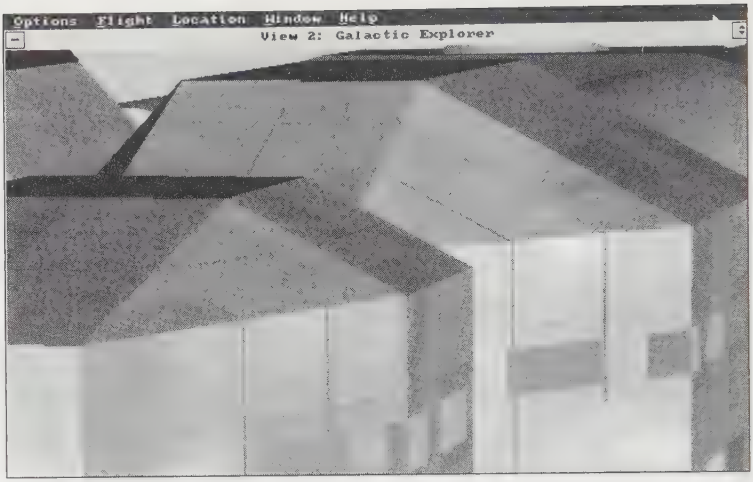

Options Flight Location Window Help
View 2: Galactic Explorer

Figure 4-21 Spacecraft Close-up. *Note the remarkable detail of the spacecraft in the* Space Simulator *fleet. In this shot, you can see the intricate shading of the* Galactic Explorer*'s precision-engineered hull panels.*

15. When you're done examining the hull of the *Galactic Explorer*, click the double-arrow button in the corner to bring back the original screen.

OK, your ship's undamaged, and you've completed your assigned data scan of Venus. The third planet from the Sun is Earth, which requires no data scan. The fourth planet, Mars, figures prominently in next chapter's mission, so we'll skip it too.

What's next?

On to the giant planets, Jupiter and Saturn.

Jupiter

The largest planet of our Solar System is also the most visually dramatic. Vast, colorful streaks of gas swirl about Jupiter's circumference at tremendous speeds. Its twirling, mysterious Great Red Spot is now believed to be a super-hurricane, a storm so big it could easily engulf three Earths in its maelstrom.

Indeed, Jupiter is enormous. You could stuff roughly 1,300 Earths inside its hollow globe. Interesting, then, that Jupiter's mass is only three hundred times that of the Earth. This indicates that it is far less dense than our planet—and in fact, *Voyager* data has confirmed that Jupiter is mostly hydrogen and helium, the lightest of all elements.

As before, you can alter some view features so you can keep an eye on Jupiter as you approach the spectacular gas giant:

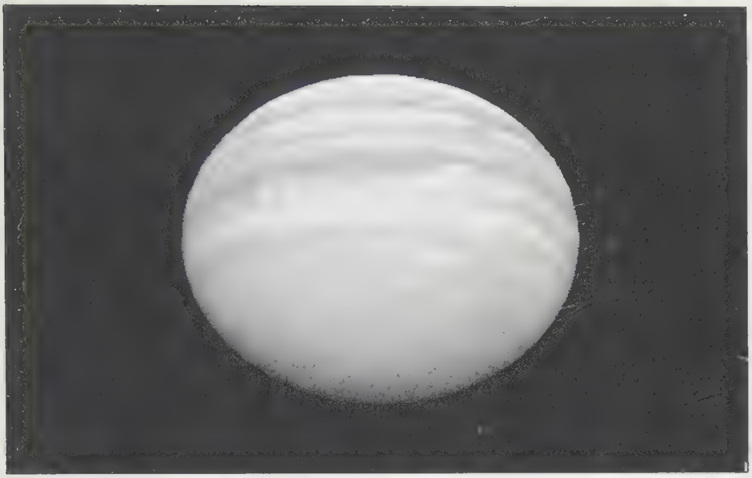


Figure 4-22 Jupiter. *The big guy. Giant gaseous storms, no solid surfaces, crushing gravity. Let's keep our distance.*

1. Select View Controls from the Window menu and click on the View 1 button at the top.
2. Under View Location, click on the Cockpit button.
3. Change Tracking Object to Jupiter. Click OK.
4. Now click the Map View button and change Map Origin to Jupiter. Click OK twice.
5. Select Arrange from the Window menu and click on the Map View box. Click OK.
6. On the Map View window, click the Zoom Out button ten times until the zoom scale reads 70.4 mkm.
7. Finally, select View Controls from the Window menu again and click on the View 2 button at the top. Then switch Chase Craft Perspective from Relative to Absolute, and be sure View Direction is set to Tracking. Click OK.

Now you can watch the *Galactic Explorer*'s approach of Jupiter from three vastly different perspectives. Time to disengage from your Venusian orbit and head off for the largest planet in the Solar System:

8. Choose Autopilot from the Flight menu and change Current Destination to Jupiter. Be sure both the Reference Object and Tracking Object boxes have an X in them, for updating.
9. Select Orbit from the Action list.

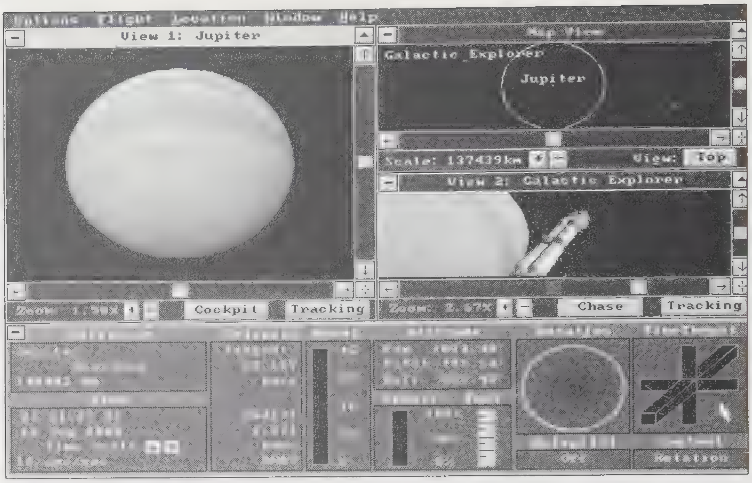

Options Flight Location Window Help
View 1: Jupiter
Map View
Galactic Explorer
Jupiter
Scale: 137439km
View: Top
View 2: Galactic Explorer
Zoom: 1.30X
Cockpit
Tracking
Zoom: 2.57X
Chase
Tracking
Off
Rotation

Figure 4-23* *A Plethora of Windows. *Three different perspectives on your Jupiter mission segment keep the viewing lively.*

10. Change the orbital radius to 2 radii for Jupiter orbit, and click the Distance from Center button. Click OK.
11. Click on Execute.

You're off to Jupiter. Along the way, keep an eye on your View 2 window. The Absolute perspective of the chase craft camera lets you see precisely how Autopilot steers the *Galactic Explorer*, flipping it this way and that for various course adjustment and orbital burns.

In fact, it might be kind of fun to maximize your View 2 window and shoot a few frames of video here—a nice, kinetic shot.

12. When you get close to Jupiter, increase the scale of the Map View window to 1.1 mkm, then open the Window menu and select View Controls.
13. Click on the Map View button at the top, then click on the Moons box to put moons on the map. Click OK.
14. After Autopilot puts you in a stable orbit and turns itself off, increase your Time Scale setting to 34.1 minutes/sec.
15. At the bottom of the Map View window, toggle the View setting to Top. Then click the Maximize button at the upper right.

Now watch the orbital dance of the inner Jovian system as your *Galactic Explorer* joins three of Jupiter's moons, Amalthea, Io, and Europa in their spin around the mother planet.

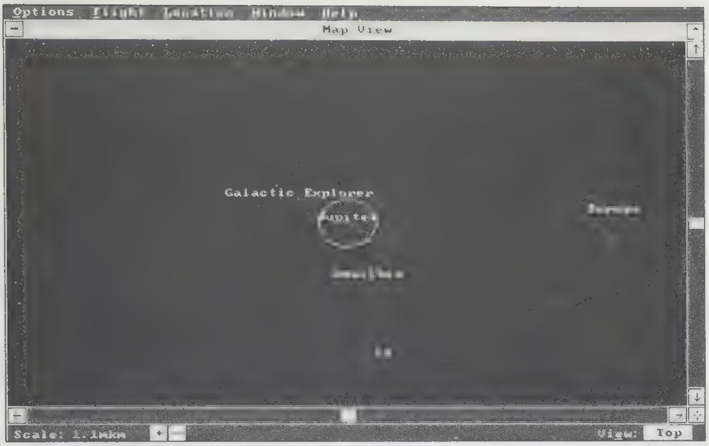


***Figure 4-24* Orbital Dance.**
Join Amalthea, Io, and Europa in a whirling dance around that big ball of liquid hydrogen named for the king of the gods.

Reminder: Here's another good place to shoot some video. Just press U to unpause your recording, let ten or twenty frames roll, then press U to pause the recording again.

Your Jupiter scan is complete. But before heading off to Saturn, let's pull another view out of our view tool bag of tricks. Suppose you wanted to make a side-by-side comparison of Jupiter and Saturn. How would you do it?

Remember, your Assigned view location lets you see the view from any object in the Space Simulator universe. To select an Assigned view location for any particular window, you press the A key. So do the following:

16. Minimize the Map View window, then click on the View 2: Galactic Explorer window to be sure it's active and press A.
17. Choose Moons from the Object Type list, then select Amalthea from the list box. Click OK.
18. Toggle the View Location setting in the View 2 window to Assigned and be sure the View Direction is tracking.

Your View 2 window will now display the view from Amalthea, Jupiter's closest moon. If Jupiter is already your View 2 Assigned Location tracking object, you should find yourself gazing at it now in the View 2 window. If not, do the following:

19. Press T.
20. Under Object Type, choose Planets.
21. Select Jupiter from the list, then click OK.

Jupiter is now locked in your View 2 sites. Maximize the View 2 window and shoot a few frames of video. Then let's move on to Saturn and set up a comparative look at the two gas giants of our Solar System.

Saturn

Saturn is a pale, gaseous planet which, like Jupiter, consists almost entirely of hydrogen and helium gas. Its surface is covered by swirling orange clouds of ammonia ice crystals. With a diameter 9 times and a mass 95.2 times that of Earth, Saturn exerts enough pull to reign in twenty-one moons, including the mysterious Titan, the only moon in the Solar System with a substantial atmosphere—denser than Earth's, in fact—and the only planetary body yet discovered whose solid surface is at least partly covered by seas.

Don't get too excited about finding life on Titan, though. The seas are liquid methane, and the temperature is a somewhat chilly 290 degrees below zero, Fahrenheit.

Saturn's famous rings, once thought to be a solid plate of matter, are actually about a trillion chunks of ordinary ice water. Nobody knows exactly how the rings formed, but most of Saturn's moons are composed of solid ice. Thus, one theory is that one or more close-orbiting moons got torn apart by Saturn's tremendous gravitational pull, leaving rings of frozen debris.

Again, let's adjust the view so that you can watch Saturn during your approach:

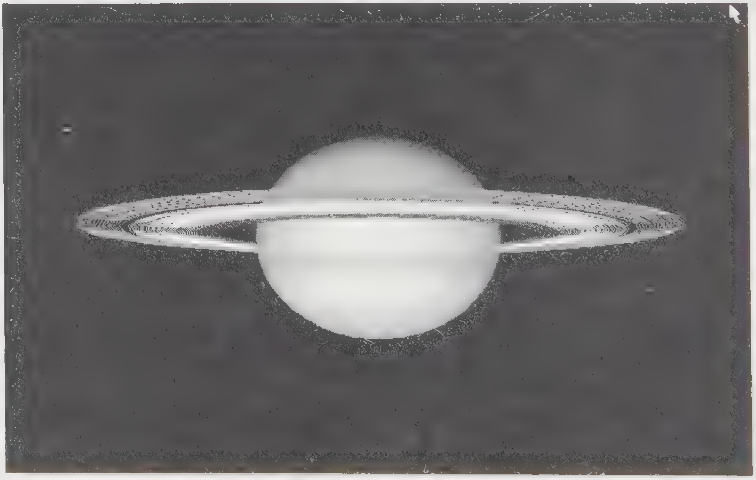


***Figure 4-25 Saturn.** This graceful giant is the sixth planet from the Sun. Astronomers once thought it had about six layers of rings;* Voyager *photos revealed something like 100,000 rings.*

1. Select View Controls from the Window menu and click on the View 1 button at the top.
2. Be sure the View Location: Cockpit button is turned on, then change Tracking Object to Saturn.
3. Now click the Map View button and change Map Origin to Saturn. Click OK twice.
4. On the Map View window, set the zoom scale to 1.1 mkm.

Now let's head for Saturn:

5. Choose Autopilot from the Flight menu and change your Current Destination to Saturn. Be sure both the Reference Object and Tracking Object boxes have an X in them, for updating.
6. Select Orbit from the Action list.
7. Set the orbital radius to 4 radii for your Saturn orbit and click the Distance from Center button. Click OK.
8. Change your Orbital Inclination setting to 10.00 degrees. (This gives you a more dramatic view of the rings.) Click OK.
9. Click on Execute.
10. For fun, you can maximize the Map View window to watch the *Galactic Explorer* weave its way down through the six closest moons of Saturn into a stable orbit.

Reminder: Here's another good place to shoot some video. Just press U to unpause your recording, let ten or twenty frames roll, then press U to pause the recording again.

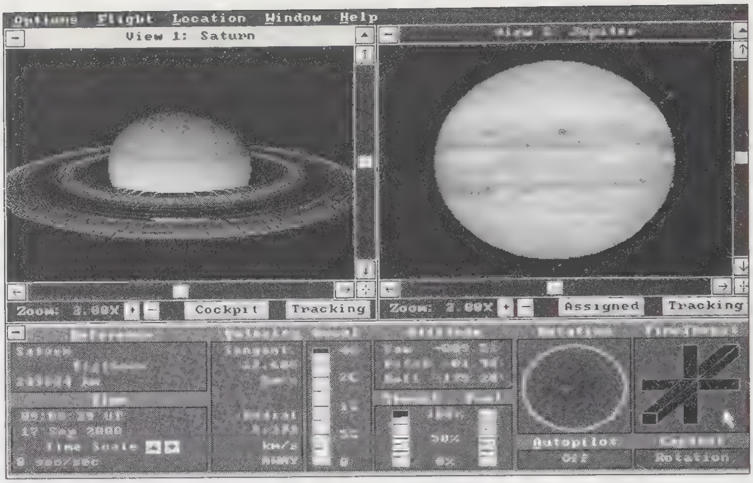
11. Click the double-arrow button anytime to bring back the original screen view.

Comparing Saturn and Jupiter

Once Autopilot puts you in a stable orbit and turns itself off, you can get the two gas giants rotating side-by-side.

12. Close the Map View window. (Click on the close button in the upper-left corner of the window.)
13. Increase the Time Scale setting to about 34.1 minutes/sec to enjoy a rotating globe effect of both planets.

__Figure 4-26 Two Gas Giants.__ Here's a side-by-side comparison shot of Jupiter and Saturn, thanks to the handy Assigned view function, which lets you place and aim a camera anywhere in the Space Simulator universe.



As an alternate method, you can click on the View 1: Saturn window to make it active, then press A (to set Assigned view) and select Moons from the Object Type list. Scroll to Mimas and click on it, then click OK. Now press T (to set the tracking object) and select Planets from the Object Type list. Click on Saturn, then click OK.

Now you have side-by-side shots of Jupiter and Saturn as seen from two of their respective moons. The shots are roughly equidistant: Mimas is an average of 185,500 kilometers from Saturn; Amalthea an average of 181,000 kilometers from Jupiter. So if your Zoom settings are the same (2.00X works best), you can compare the two planets by size.

Uranus, Neptune, and Pluto

The icy outer planets of the Solar System are quite beautiful and interesting in their own frigid way. I highly recommend that you continue your data-scanning journey on your own at this point. Play with the view windows until you can manipulate them easily. The Space Simulator universe is a beautiful one, once you learn how to view it.

Reminder: Each of the view windows—View 1, View 2, and Map View—has its own set of view tools. You can set different view locations and directions, zoom settings, panning angles, and so on, for each of them. Also remember that you can select a separate tracking object for each view location—Cockpit, Chase, and Assigned—in each view window.

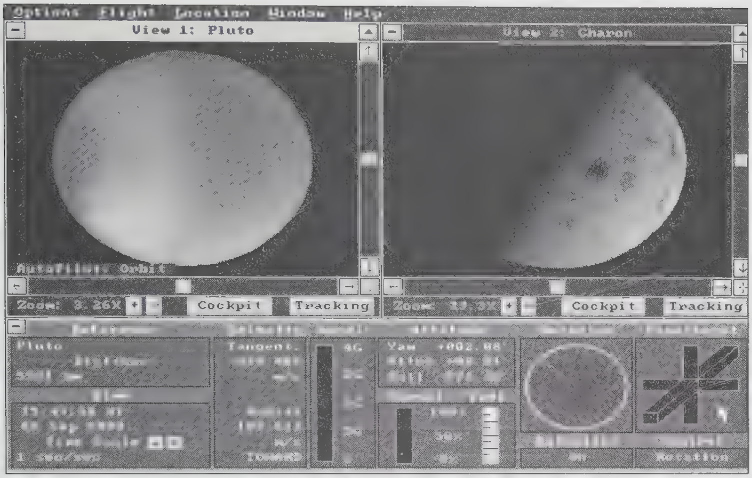


Figure 4-27 Tour the outer planets. *Here's a side-by-side look at Pluto, the farthest planet from the Sun, and its single moon, Charon.*

Note: Since *Space Simulator* maintains a separate Tracking Object for Cockpit, Chase, and Assigned view locations, the Tracking Object listed in the View Controls dialog should change as you click on each of the three views listed in the dialog box. But it doesn't.

The result of this is that if you have different tracking objects set for two (or all three) view locations of a window, you'll lose them if you change the view location in the View Controls dialog, and then close the dialog (OK) without correcting the Tracking Object to what you want *for that view location.*

Once the problem is understood, there is a simple workaround, other than always checking your Tracking Object before you close the dialog. *Never change the View Location from the View Controls dialog;* that is, always be sure the View Window you are interested in is set to the desired View location *before* you open the View Controls dialog.

Don't forget to shoot a few frames of video here and there as you scan the outer worlds of Uranus, Neptune, and Pluto. Then, when you complete your mission:

1. Select Video Recorder from the Options menu.
2. Find and click on SOLARSYS in the File list. (SOLARSYS should appear in the File Name box at the top.)
3. If you want your recording to loop (play over and over again), be sure to click on the Looping Playback box.
4. Click the Play button and enjoy the show.

Chapter 5

Flight Controls

Mission: The Pirates of New Phobos

Now that you can use your *Space Simulator* windows, it's time to learn some flight skills. Up to this point you've relied entirely on Autopilot. Are you ready for some hands-on star-piloting? I hope so. Your future in Fleet Command depends on it.

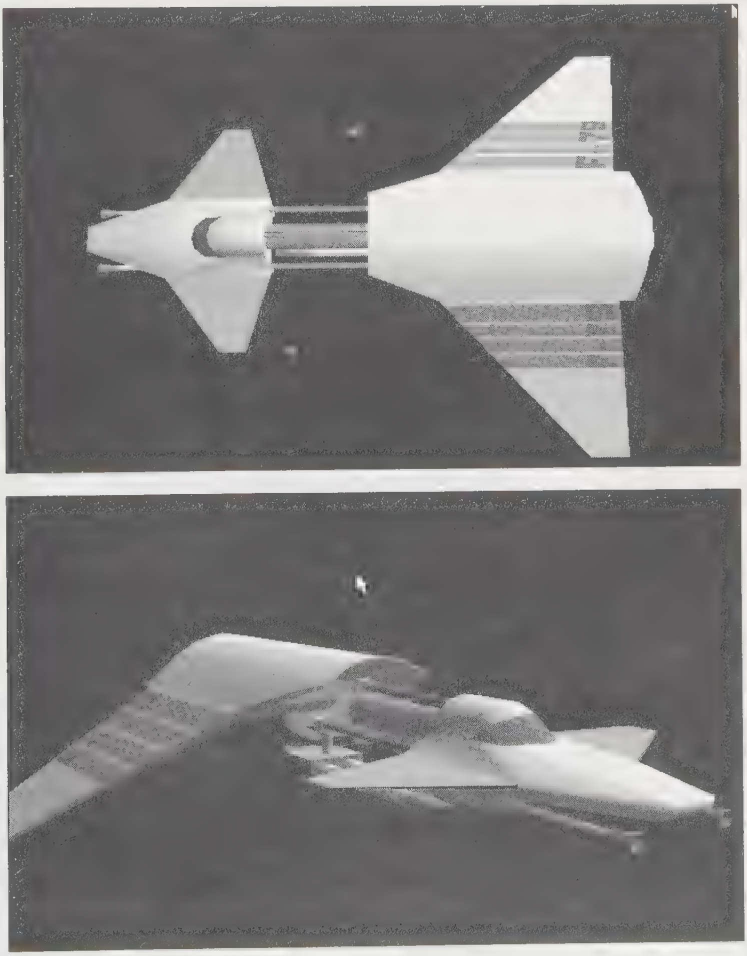


Figure 5-1 F-79 Galactic Fighter. *Fly to Mars in a sleek new thrust-monster sporting 8 g's of acceleration under the hood. Your mission: Investigate a space station suddenly gone silent.*

Of course, it's entirely possible to enjoy *Space Simulator* without ever touching a thruster button. After all, even space shuttle astronauts do very little actual piloting. Space travel is a complex endeavor. It involves such high velocities and precise orbital calculations that most flight decisions are best left to computers.

But what self-respecting space simulator wouldn't make it fun to hop in, grab a joystick, and explore? Total freedom of movement in a true-to-life, true-to-astrophysics universe is one of *Space Simulator*'s great assets. Just point your nose at a star, blast off, and go check it out.

This chapter starts off with a quick review of all your spaceflight and slew controls (which are virtually the same). Perhaps the most important controls to learn first are your three "Stop" keys. These keys—which are, in effect, cheat keys—will be so important during your rookie pilot phase that I want to discuss them right away.

STOP KEYS

Spaceflight is not like atmospheric flight. There are no aerodynamic considerations, because there is no "aero" to be "dynamic." In the vacuum of space, nothing retards the acceleration or velocity of your starship when you apply your thrusters. You just go. And as Isaac Newton pointed out, you keep going until you crash into something, or until you apply some sort of force in the opposite direction.

How do you stop a spaceship? In real space, you apply reverse thrust in direct proportion to the thrust that got you moving in the first place. In *Space Simulator*, you can do the same, or you can press the Stop keys.

The Stop keys are:

Action	**Keystroke**
Stop thrust	Home or F5
Stop velocity	F4
Stop roll, pitch, yaw	Keypad 5 or F3

I really can't stress this enough: These keys will save your rookie tail time and time again.

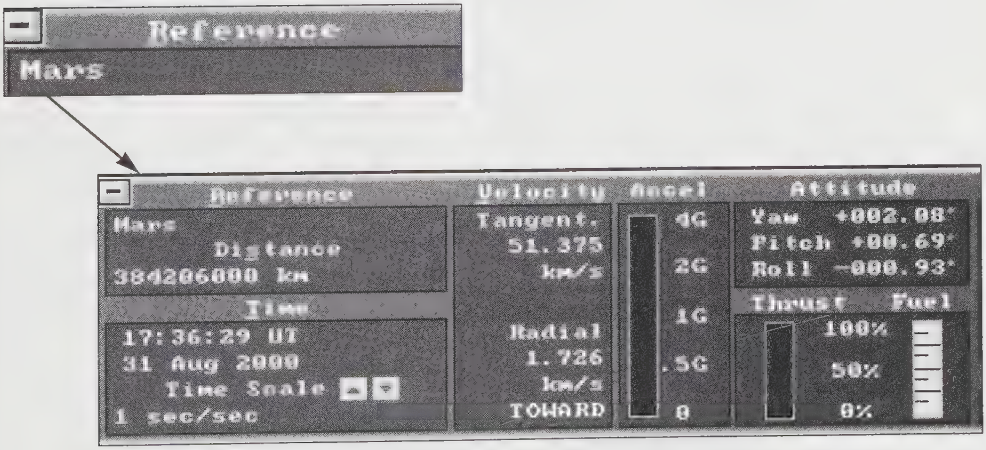
Now, I called them cheat keys, but are they really? A Stop Thrust button is not necessarily a cheat. You can cut thrust immediately in most controlled propulsion systems, even today. And I suppose it is possible to envision some sort of multidirectional thruster technology that would allow you to halt a roll, pitch, or yaw motion pretty quickly.

But by no stretch of the imagination could a Stop Velocity button ever exist. The only force that could instantly halt a fully loaded, 100,000-ton *Zander Freighter* hurtling through interstellar space at .5 C (half the speed of light, about 150,000 kilometers per second) without demolishing it and everyone inside would be—well, maybe Einstein could figure it out—some sort of Relativistic Time Beast, or God, or whatever. The point is, your F4 key is 100 percent pure cheat. And it's beautiful.

THE REFERENCE OBJECT

One other navigational feature should be mentioned right away. You've already seen how important the reference object is to the configuration of your view tools. In terms of spaceflight navigation, it is even more important.

In this chapter, you will read time and time again the phrase "in relation to the reference object." That's because most significant measures of your position in space will derive their meaning in relation to your currently designated



Reference: Mars

Distance 384206000 km

Time: 17:36:29 UT

31 Aug 2000

Time Scale 1 sec/sec

Velocity: Tangent. 51.375 km/s

Radial 1.726 km/s TOWARD

Yaw +002.08°

Pitch +00.69°

Roll −000.93°

Figure 5-2 Reference Object. *Most of the numerical readouts on this instrument panel only make sense in relation to one thing—the object listed under Reference in the upper-left corner.*

reference object. Attitude (yaw, pitch, and roll), distance, radius, altitude, radial and tangential velocity—all of these are measured to some degree in relation to the reference object listed.

Almost all of the Autopilot functions—orient, prograde, retrograde, rendezvous, orbit, land, dock/undock—also relate directly to the reference object you've selected. (You'll read more about Autopilot in Chapter 6.)

FLIGHT CONTROLS

Understanding *Space Simulator*'s flight controls is much easier than figuring out its view controls. Flying a spacecraft is simple, really. The secret lies in understanding the way bodies move in the frictionless vacuum of space. Once you get the hang of it, it's a lot of fun.

Remember, this is a strategy guide, not a manual. All of the flight controls, as well as basic spaceflight concepts such as thrust, velocity, acceleration, pitch, yaw, roll, and so on, are explained in your *Star-Pilot's Guide*. The following is more of a quick review.

Thrust

Thrust is the engine power that pushes you forward. When fuel burns in its engine compartment, it expands rapidly and escapes through an exhaust nozzle. This escape action pushes your starship in the opposite direction, which is the equal and opposite reaction of Newton's Third Law.

Note: Remember that in *Space Simulator*, you can only apply thrust with the keyboard.

Like the space shuttle orbiter, all *Space Simulator* starships are outfitted with two different sets of thrust engines. Main engines are quite powerful,

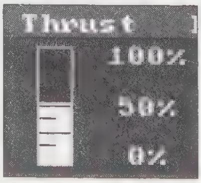


Figure 5-3 Thrust Gauge. *This gauge shows you what percentage of your engine's total propulsive power you're using.*

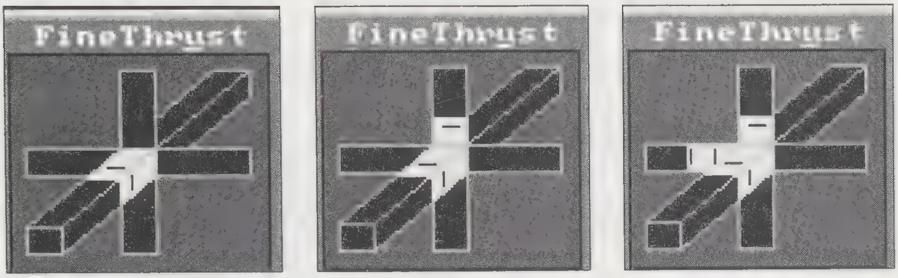


Figure 5-4 Fine Thrust Gauge. *Use combinations of the directional thrusters to apply fine thrust in any direction.* Left: *Here's your fine thrust gauge after you add backward thrust.* Middle: *Add some upward thrust; you're now moving diagonally back and up.* Right: *Finally, add a little leftward movement to the mix.*

regardless of the ship. You'll use them for most of your general navigation. They only fire in one direction, however, so you'll have to pitch or yaw your ship's nose the way you want to go before applying main engine thrust.

For more delicate maneuvers, such as docking procedures, you can use your fine thrust engines. These are multidirectional, like those on the space shuttle, so you don't have to pitch or yaw the ship first. Just fire the appropriate minithruster to move the entire spacecraft up, down, left, right, forward, or back. Or you can fire combinations of thrusters—up and left, for example—to move diagonally.

Main Engine Thrust

Note: Be sure your Num Lock is toggled off! Otherwise, your non-keypad keys may trigger power-panning rather than thrust commands.

Here are the keystrokes that control your powerful main engines:

Action	**Keystroke**
Increase thrust	Keypad + or F7
Decrease thrust	Keypad - or F6
Full thrust	End or F8
Stop thrust	Home or F5

Fine Thrust Engines

Here are the keystrokes that control your fine thrust engines:

Action	Keystroke
Forward	Shift + Keypad +
Backward	Shift + Keypad −
Up	Page Up
Down	Page Down
Left	Insert
Right	Delete
Stop	Home or F5

Pitch, Yaw, and Roll

Pitch, yaw, and roll refer to various rotations of your spacecraft. The combination of your spacecraft's pitch, yaw, and roll—in other words, the way the ship is positioned in space—is called its *attitude*.

Measuring your ship's attitude in relation to its current reference object is quite useful for space navigation, as you'll see later. The rotations of pitch, yaw, and roll are measured by two different instruments on your ship's instrument panel—the Attitude display and the Rotation gauge.

Pitch

Pitch refers to the up/down rotation of your ship's nose. To pitch your spacecraft:

Action	Keystroke
Pitch down	↑
Pitch up	↓
Stop pitch	Keypad 5

Yaw

Yaw refers to the left/right swing of your ship's nose. To yaw your spacecraft:

Action	Keystroke
Yaw left	←
Yaw right	→
Stop yaw	Keypad 5

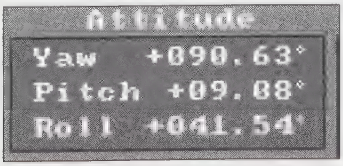
Roll

Roll is the action of spinning your ship around its longitudinal axis (an imaginary line running right down the center of your ship, nose to tail). To roll your spacecraft:

Action	Keystroke
Roll left	Keypad /
Roll right	Keypad *
Stop roll	Keypad 5

Attitude Display

The numeric Attitude display shows the number of degrees your spacecraft has rotated in relation to your reference object. In particular, it marks how far your ship's nose has rotated up/down (pitch) and left/right (yaw) from your current reference object, and how far your craft has rolled left or right in relation to the equator of the current reference object.



```
Attitude
Yaw    +090.63°
Pitch  +09.08°
Roll   +041.54°
```

Figure 5-5 Attitude Display. *This readout measures the rotational movements of your spacecraft—yaw, pitch, and roll—in relation to your current reference object.*

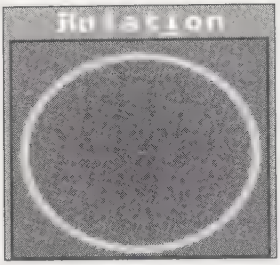


Figure 5-6 Rotation Gauge. *This gauge registers the direction and degree of any current rotation of your spacecraft.*

Rotation Gauge

The Rotation gauge (blue circle) on your instrument panel graphically displays the direction and speed of any current rotation of your spacecraft.

Note: Attitude has nothing to do with velocity. Your ship could be yawing, pitching, and rolling wildly, yet still not be going anywhere. You might be rotating around a single unmoving point—dead in space, velocity-wise, despite all the movement.

Slew Control

As you know from Chapter 5 of your *Star-Pilot's Guide*, slew control gives you freedom from gravity and the laws of motion. Since Microsoft devotes an entire chapter to "Slewing Through Space," I will have little to add here.

Let me simply reiterate that slew control uses the same keystrokes for thrust, pitch, yaw, and roll as does regular flight control. But your thrust increases quite differently when slewing. The concept of acceleration is eliminated, in fact. You simply leap to velocities that double with each stroke of the thruster key.

Another important difference: This instantaneous velocity is produced equally by all thruster keys in slew control. That includes your fine thrust engines as well, which means that you can rocket in any direction (including reverse) at phenomenal speeds without having to point your ship in the direction you're going!

Activating Slew Control

To activate slew control, open the Flight menu and select Slew Control. After you do this, the menu item will change to read Flight Control. Open the Flight menu again and select Flight Control when you want to return to regular flight controls.

Slew Control Velocity Table

I've created a velocity table for slew control, shown here. As you can see, the first stroke of any thruster key propels your spacecraft to a velocity of .279 meters per second. Each additional keystroke then doubles the previous velocity, all the way up to the thirty-first tap of the key, which puts you at your maximum velocity of 299,792 kilometers per second—just .5 kilometers per second slower than the speed of light.

Table 5-1 Slew Control Velocity

Thruster Keystroke	Velocity
1	0.279 m/s (meters per second)
2	0.558 m/s
3	1.117 m/s
4	2.234 m/s
5	4.467 m/s
6	8.935 m/s
7	17.869 m/s
8	35.738 m/s
9	71.476 m/s
10	142.952 m/s
11	285.905 m/s
12	571.810 m/s
13	1.144 km/s (kilometers per second)
14	2.287 km/s
15	4.574 km/s
16	9.149 km/s
17	18.298 km/s
18	36.596 km/s
19	73.192 km/s

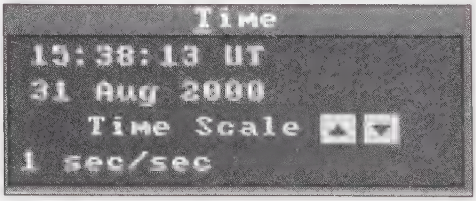
Table 5-1 Slew Control Velocity *(continued)*

Thruster Keystroke	Velocity
20	146.383 km/s
21	292.767 km/s
22	585.533 km/s
23	1171 km/s
24	2342 km/s
25	4684 km/s
26	9369 km/s
27	18,737 km/s
28	37,474 km/s
29	74,948 km/s
30	149,897 km/s
31	299,792 km/s

Note: These keystroke/velocity numbers apply to all thruster keys in slew control, including fine thrust. Notice that each successive keystroke doubles the velocity achieved.

Time Scale

Speed up the passage of time for those deep space excursions by increasing the Time Scale setting on your instrument panel. This powerful tool is one you will use frequently. After all, the cosmos is majestic, but there's an awful lot of nothing in it too. Even at the speed of light, matter's maximum speed limit, it would take you 4.3 years to reach Proxima Centauri, the nearest star to our Sun. *Space Simulator* would be terribly limited without a time machine to close up those yawning chasms of emptiness between celestial bodies.



15:38:13 UT
31 Aug 2000
1 sec/sec

***Figure 5-7 Time Scale.** Give the up arrow on this display a few clicks to speed up any trip. Use it carefully, though. If you increase the scale too far, you can lose control of your ship.*

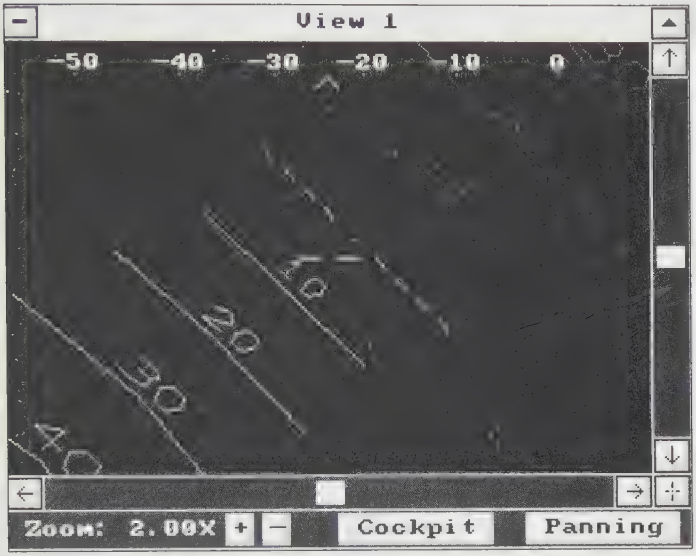


Figure 5-8 ***Head-Up Display.*** *This navigational display on your Cockpit window lets you adjust yaw, pitch, and roll readings without taking your eyes from the celestial view.*

Head-Up Display

The Head-Up display is a visual navigation device that you can superimpose on your window in Cockpit view. It gives you a graphic picture of your spaceship's attitude in relation to your current reference object. This lets you "zero in" on the object—that is, adjust your yaw, pitch, and roll to 000.00 degrees—without removing your gaze from the Cockpit view window.

The Head-Up display only works if:

- Your view location is Cockpit
- Your view direction is toggled to Panning mode
- The horizontal and vertical panning bars are centered.

Activating the Head-Up Display

Choose Cockpit as your view location, toggle the view direction to Panning mode, and be sure both panning bars are centered. Then select Show Head-Up Display from your Window menu.

- **Yaw** The *green number display* across the top of the view window measures your yaw in relation to your reference object. The display measures your ship's yaw in positive degrees (yaw right) and negative degrees (yaw left).

The yellow arrow centered at the top of the window marks the current yaw reading, which matches the number in the Yaw readout of your Attitude display.

- **Pitch** The *blue/red attitude grid* measures your pitch in relation to the reference object. The grid is laid out in 10-degree increments, with blue numbers measuring positive degrees of pitch (pitch up) and red numbers measuring negative degrees of pitch (pitch down).

The yellow line in the center of the View window marks the current pitch reading; this matches the number in the Pitch readout of your Attitude display.

- **Roll** The blue/red attitude grid also rotates to give you a visual representation of your roll attitude; the grid rotation matches your rate of roll. The dotted green line (found between the -10 and +10 grid lines) represents 000.00 degrees of roll, in relation to the equatorial plane of your current reference object.

MISSION: THE PIRATES OF NEW PHOBOS

Something odd is happening aboard Fleet Command's brand new *Mars Orbiter.*

On-line now for only two months, the state-of-the-art orbital lab/observatory has suddenly gone dead silent. An advance crew of NASA engineers, preparing the station for permanent habitation, no longer responds to hailing transmissions.

Yet the Orbiter's control systems—life-support, power plant, navigation and robotic controls—read out as fully operational. Everything is responsive and seems normal. Everything, that is, except the video surveillance system. None of the cameras transmit picture, except for the one in the docking port. It shows nothing out of the ordinary.

Where is everybody?

Your mission: Find out.

Of course, Fleet Command doesn't know what to expect, so you are assigned an *F-79 Galactic Fighter*, with its hard-core weaponry and a hot new antimatter drive that can kick out blistering 8-g bursts of acceleration, if necessary. Your crew of two is nervous. So are you. Hey, so am I.

Mission Step 1: Yawing the Night Away

Before setting off on your journey, take your shiny new starship for a quick spin—literally. You can have some centrifugal fun while getting a working understanding of pitch, yaw, and roll. You'll use the slew controls for this purpose, so you can hang motionless in space near your first reference object, Earth, using it as a helpful backdrop.

Note: If you're new to spaceflight, you might want to stay in Practice mode. It will make the docking procedure in this chapter much easier to negotiate. But if you want a real challenge, you can open the Preferences dialog box from the Options menu, click on Skill Level, and switch to Intermediate or Advanced.

1. Select Open Situation from the Options menu and highlight the FLIGHT situation. Click OK.
2. Select Slew Control from the Flight menu or press the Y key.

When this situation opens, you are viewing Earth and Ring Station 1 from the cockpit of the *Galactic Explorer*. This is the ship from which you've just been transferred. But it's easy enough to comply with your new fleet assignment.

3. Select Spacecraft from the Flight menu, then choose *F-79 Galactic Fighter* from the menu. Click OK. You are now the proud captain of a gleaming new *F-79 Galactic Fighter*.
4. Switch your view location to Chase.

Now you should have a view from behind the F-79. The ship's nose should be roughly centered on your reference object, Earth, which is about 25,300 miles away. If this is not the case, then check the following:

- Make sure Earth is your reference object.
- Make sure the *F-79 Galactic Fighter* is your Chase view tracking object.

5. Select View Controls from the Window menu and be sure the View 1 button (at the top) and Chase Craft button (under View Location) are both clicked on.
6. Switch Chase Craft Perspective from Relative to Absolute, and set Chase Craft Distance at about 2. This way you can watch the change in your ship's attitude to the Earth as you pitch, yaw, and roll. Click OK.

7. To quickly get your ship's nose zeroed in on Earth, select Autopilot from your Flight menu and click on Orient. Be sure the Update box for Tracking Object does not have an X in it. (You don't want to update your tracking object, since you just set it to your *F-79*.) Click Execute.
8. Slide the horizontal panning bar to the right until you are roughly behind the *F-79*, with the Earth prominent in the window. Now slowly roll the *F-79* to the left by pressing Keypad [7] until the Roll readout on your Attitude display is at 000.00, then quickly press Keypad [5] to stop the roll.

See how your ship lines up horizontally with the Earth's equator? A zero Roll setting always means Left-to-Right alignment with the equatorial plane of your current reference object.

Now let's play with the attitude a bit:

9. Roll right in a full circle and note the Attitude display Roll readout. The right half of the rolling arc registers in positive degrees, the left half in negative degrees.

At both +90.00 and -90.00 your ship's "horizon" is perpendicular to the Earth's horizon. At 180.00, your ship is "upside down." (Of course, there's no up or down in space. The 180.00 degrees merely refers to your ship's horizontal orientation to the reference object.)

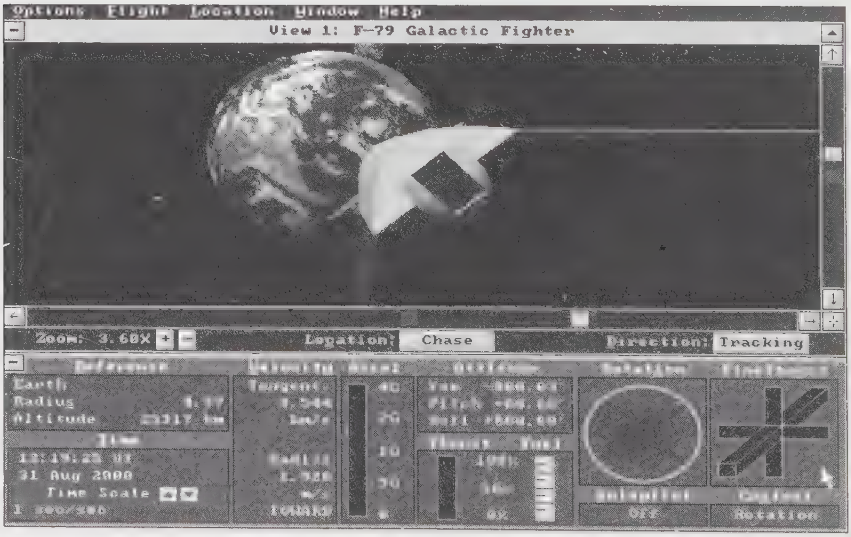

Options
Flight
Location
Window
Help
View 1: F-79 Galactic Fighter
Zoom: 3.60X
Location:
Chase
Direction:
Tracking
Earth
Radius
Altitude
Tangent
Time
31 Aug 2000
Time Scale
OFF
Rotation

Figure 5-9 *Depending on your computer, it may be difficult to get a perfect 000.00 reading for roll, pitch, or yaw with hands-on piloting. Just get as close as you can.*

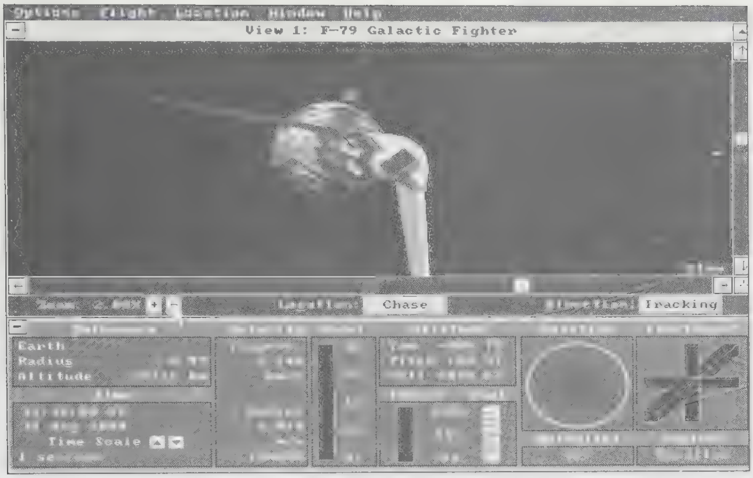
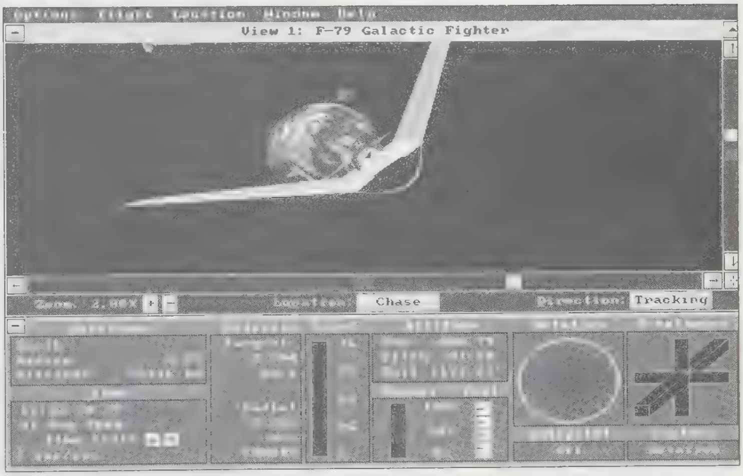
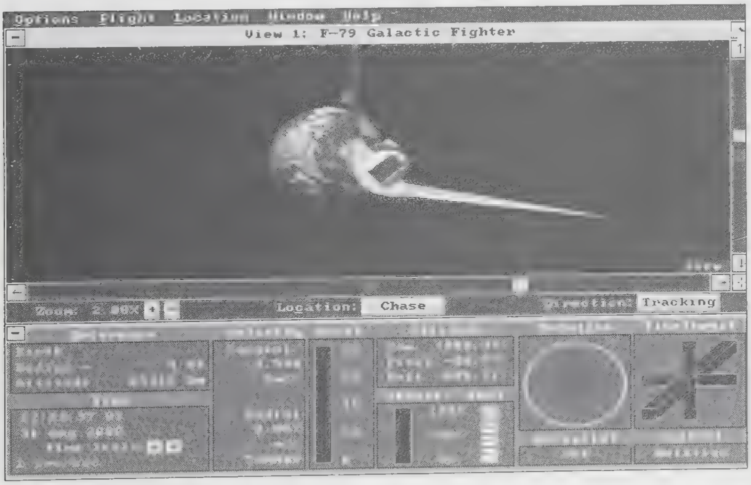

Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Location: Chase
Direction: Tracking
Earth
Radius
Altitude
Time Scale

Figure 5-10 ***Rolling for Dollars.*** *This series of shots shows your F-79 rolled to approximately +90.00* (top), *180.00* (middle), *and -90.00* (bottom). *As you roll your craft a full 360 degrees, note the Roll readouts in the Attitude display. (Your reference object, Earth, is in the background.)*


Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Zoom: 2.00X
Location: Chase
Direction: Tracking

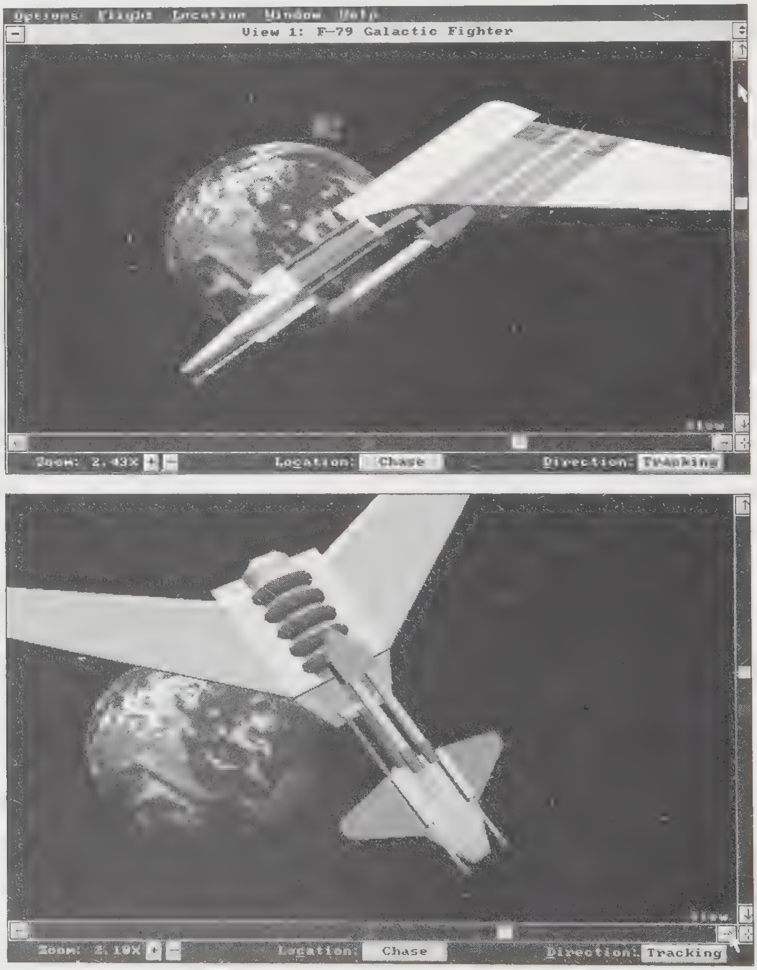

Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Zoom: 2.00X
Location: Chase
Direction: Tracking

10. Roll the ship back to a zero Roll reading. Now yaw the ship around in a full 360-degree circle.

Again, note the Attitude display as you yaw. Yawing the nose to the right of Earth registers as positive degrees (000.00 to +180.00). Yawing to the left of Earth registers as negative degrees (000.00 to -180.00).

11. Yaw the ship back to approximately 000.00 degrees. Now pitch the ship up and around in a half-circle.

The Attitude display registers a pitch-up attitude as positive degrees—from 000.00 degrees when the nose points directly at the reference object, rising up


Options Flight Location Window Help
View 1: F-79 Galactic Fighter

Zoom: 2.43X Location: Chase Direction: Tracking

Zoom: 2.10X Location: Chase Direction: Tracking

Figure 5-11 Yaw and Pitch.
Top: *Here's a view of your ship after yawing left to -90.00 degrees.*
Bottom: *Here's your* F-79 *pitched down to -90.00 degrees, revealing its underbelly, including the hexagonal docking port.*

to +90.00 when the nose points straight "up" (in the same direction as the reference object's north pole), then back down to 000.00 as the nose rotates back down and directly away from the object.

A pitch-down attitude registers as negative degrees—from 000.00 degrees when the nose points directly at the reference object, dropping down to -90.00 when the nose points straight "down" (in the same direction as the reference object's south pole), then back up to 000.00 as the nose rotates back up and directly away from the object.

OK, that's enough fooling around. You have a mission to complete. Something's awry at the *Mars Orbiter*, and everyone's counting on you to straighten things out.

Now let's see what an *F-79* can really do.

Mission Step 2: Get the Right Attitude

So, off to Mars. But how? Just point your nose at it and go?

In essence, yes. It's that simple.

Of course, there are a few considerations. Gravity, for one. But on this trip, once you escape Earth's pull, you're pretty free and clear of any significant course-altering gravitation. Another consideration: Mars happens to be a moving target, clipping along around the Sun at about 15 miles per second.

You could just open the Location menu, select Space Stations, pick Mars Orbiter from the file list, and click OK. Zap! You're there in the blink of an eye (plus the processing time of your CPU). Or you could use Autopilot. But you're a fleet captain, and that would be embarrassingly wimpy.

Heck, until you get to Mars you're not even going to use Slew control or the F4 cheat key. No, this will be some genuine rocket-jockey flying.

Piloting by the Gauges

How exactly do you "just point your nose at Mars and go?" If you really know your night sky, I suppose you could actually eyeball your route. But that would be risky, and probably foolish, since even the tiniest navigational error could send you hurtling millions of miles off course.

No, better to use your gauges. Remember how the Pitch and Yaw readouts on your Attitude display register zero degrees when your nose is dead-on to your reference object? This is how you'll keep your speedy *F-79* on track for a Mars rendezvous.

Here's how it works:

1. Click Reference on your instrument panel and change the reference object to Mars.
2. Select Flight Control from the Flight menu to turn off slew control.
3. Adjust both Pitch and Yaw readings to 000.00 (or as close as you can get) on the Attitude display.

You can see from the Distance display that you've got quite a journey ahead of you. Take note of the distance—about 384,000,000 kilometers—because star-pilots who don't slew or use flight computers need to do a little math. If you don't, you'll find yourself rocketing past Mars with no quick way to slow down.

Before you get out the calculator, though, let's rearrange the window situation a bit:

4. Select View Controls from the Window menu, click the Chase Craft button, then change Chase Craft Perspective back to Relative. Click OK, then adjust your panning bars to get the view you want.
5. Switch your view location back to Cockpit, then press T and change your tracking object to Mars.
6. Select Arrange from the Window menu and click on the View 2 or press 2 to turn on View 2, click on Map View or press M to turn on Map View boxes. Click OK.

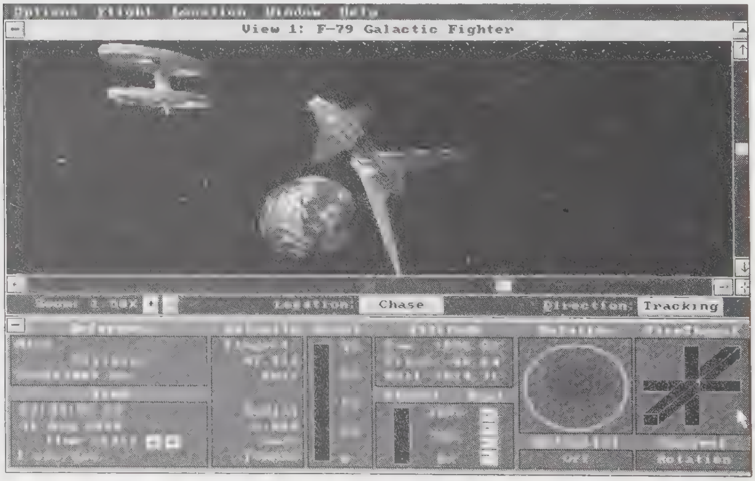


Figure 5-12 Ready for Mars Launch. *Your Reference readout is a great navigation tool. Select your destination—in this case, Mars—as the reference object. Use your Attitude display to yaw and pitch as close to 000.00 degrees as possible, which points your ship's nose at the reference object. Then thrust off, keeping your attitude "zeroed in" on Mars as you travel.*

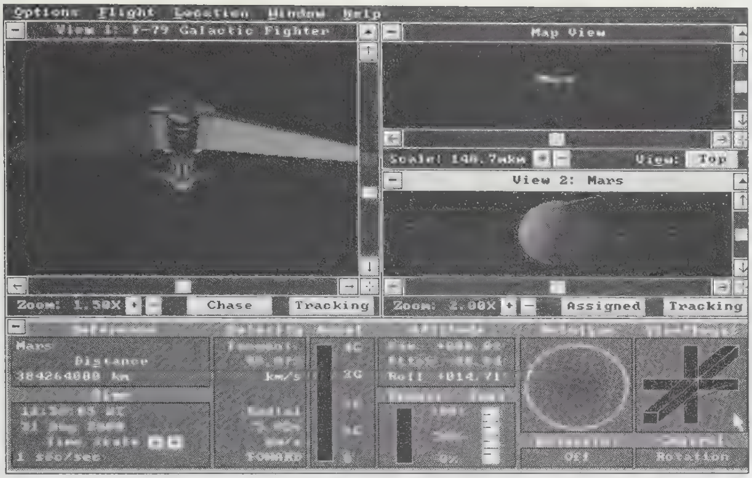

Options
Flight
Location
Window
Help
View 1: F-79 Galactic Fighter
Map View
Scale: 140.7mkm
View: Top
View 2: Mars
Zoom: 1.50X
Chase
Tracking
Zoom: 2.00X
Assigned
Tracking
Mars
Distance
384264000 km
km/s
Roll +014.71
1 sec/sec
Off
Rotation

Figure 5-13 ***Polish Your Windows.*** *Here's a nice window configuration for your trip to Mars.*

7. Click on the Map View window to make it active, then press the letter O and change the map origin to Mars. Set the view to Top and reduce the scale to 140.7 mkm, so you can track the final stages of your approach to Mars.
8. Click on the View 2 window to make it active. Set the view location to Assigned, then press A and select Phobos as the Assigned view location. Then press T and select Mars as the tracking object.

Mission Step 3: Figure Your Burn

OK, now it's math time. It's easy math, though. You don't really need a calculator. Again, your current Earth orbit leaves more than 384 million kilometers from Mars and the *Orbiter.*

Recall that your *F-79* is capable of 8 g's of acceleration. Do you remember the human physiological reactions to g-forces listed back in Chapter 2? The human body is capable of withstanding g-forces of more than 1.0 for only limited periods of time.

Now, you might fire a multiple-g burn for a few seconds during the initial thruster kick, or during certain course-altering maneuvers. But realistically, the bulk of a Mars voyage would proceed at a 1-g rate of acceleration—the first 192 million kilometers thrusting at 1 g toward Mars, the second 192 kilometers thrusting at 1 g back toward Earth to slow you down. (Remember, you have no brakes.)

Of course, all this thrusting would be impossible by today's fuel standards. Again, realistically, a spacecraft would probably only accelerate for a few hours, coast for most of the trip, then turn and fire a matching deceleration burn. Fortunately, this story is science fiction. Your *F-79* has an antimatter engine, so you'll easily have enough fuel for a round-trip to Mars at a constant acceleration of 1 g.

So let's get moving:

1. Press Keypad + (your main engine thrust key) four times to get your *F-79* accelerating at a constant rate of 1 g.
2. You're the pilot, so keep those Pitch and Yaw readings as close to 000.00 degrees as possible. It's fairly easy now, since you're traveling in real time (1 sec/sec). Keep at it until your reactions start to get instinctive.

Note: I highly recommend that you save your situation at this point, since you're about to significantly increase the Time Scale. Open up the Options menu, select Save Situation, type a new name in the File Name box, write a brief description (optional), then click OK. This way, if you really screw up, you can just click on Reset Situation in the Options menu to start over.

Star-piloting at high velocities without computerized help is no cakewalk. Even a berserk HAL 9000 might be better than thrusting around in space without a clue. So be forewarned: These next few steps are not particularly easy. You may need to pause the simulation from time to time, or even reset the situation (see the Note above) and start over a few times.

3. Increase the Time Scale setting. Don't go crazy; just give it a few clicks at a time. Get comfortable with keeping your attitude zeroed between increases.
4. Stop increasing the Time Scale when you get to about 1.1 hours/sec.

As I said before, for this particular trip, there are no major celestial bodies between Earth and Mars whose gravity can pull you significantly off course, although we *will* swing withing 50 million kilometers of the sun. So your Pitch and Yaw shouldn't stray too badly from their zero readings. (Of course, if you were using slew control, you wouldn't have to worry about gravity.) If one of your Attitude readings starts to get out of control, simply decrease the Time Scale setting four or five clicks, adjust the appropriate attitude (pitch or yaw), then fire up the Time Scale again.

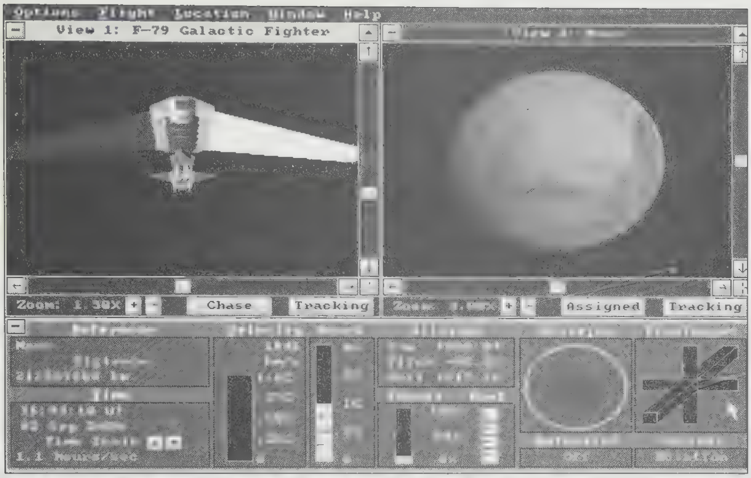

Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Zoom: 1.30X
+
-
Chase
Tracking
Zoom:
+
-
Assigned
Tracking
1.1 hours/sec

Figure 5-14 ***Tripping Through Time.*** *Trips to Mars go by a lot faster when you bring good company, good reading material, and your handy little time accelerator—set to about 1.1 hours/sec.*

5. Monitor the Distance readout as you travel. Just before you get to within 192 million kilometers of Mars, decrease the Time Scale to 1 sec/sec and decrease your thrust to zero.
6. Yaw your spacecraft around 180.00 degrees so that you're traveling tail-first toward Mars. (The Yaw readout can hover roughly between +179.00 and -179.00 degrees.) Also, make sure Pitch is set to 000.00 degrees.
7. Tap your thruster button four times to bring your acceleration up to 1 g again.
8. Increase your Time Scale back up to 34.1 minutes/sec.

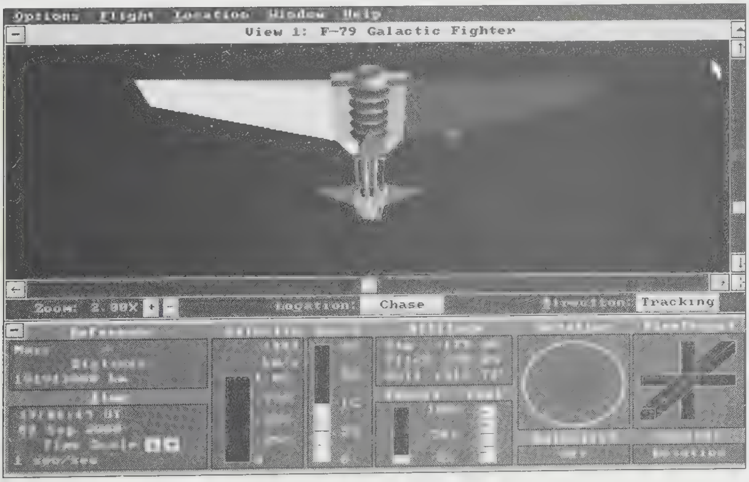
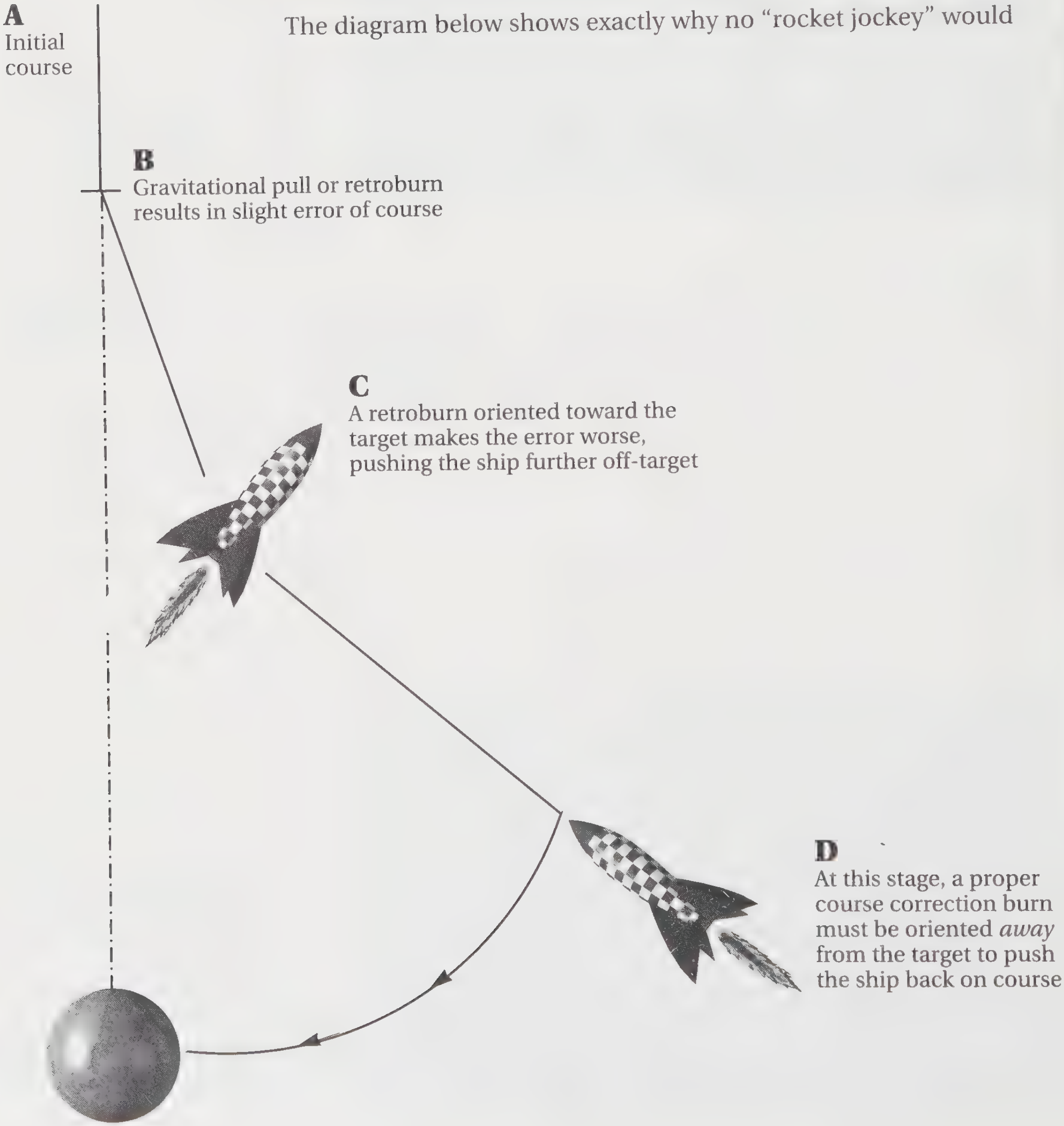

Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Zoom: 2.00X
+
-
Location:
Chase
Tracking

Figure 5-15 ***Deceleration Burn.*** *Here's how to reset your instruments at the halfway point of your voyage to Mars. At a distance of about 192 million kilometers, decrease Time Scale to 1 sec/sec, yaw around 180.00 degrees, keep Pitch at 000.00, and thrust to 1 g for your deceleration burn.*

Now you are applying main engine thrust in the direction of your flight—that is, toward Mars—to slow your ship's velocity to zero by the time you arrive at Mars. This is called establishing a retrograde orientation for a deceleration burn.

9. Keeping proper orientation during a deceleration burn is far more difficult than during acceleration or coasting. Here's why:

   The diagram below shows exactly why no "rocket jockey" would


A
Initial course
B
Gravitational pull or retroburn results in slight error of course
C
A retroburn oriented toward the target makes the error worse, pushing the ship further off-target
D
At this stage, a proper course correction burn must be oriented *away* from the target to push the ship back on course

ever be without his/her trusty Autopilot for interplanetary and certainly interstellar travel.

Suppose your initial course (A) is on-target. You cut your thrust at the halfway point, execute a 180 degree yaw turnover, then start your deceleration burn toward the Target. An almost indetectable gravity tug from a local star—or perhaps a miniscule error in your attitude alignment—results in a slight error (B) in your course. You now head slightly wide of your target. What do you do?

If you were still *accelerating* nose-first at your target, you could simply zero-in your attitude readouts again. Your thrust would eventually cancel out the residual velocity pushing you off-course, and correct the error.

But when you get off-course while decelerating, you can't just continue to point your tail at the target and thrust! This will increase your course error, pushing you further and further wide of the Target. What you'd have to do is swing the tail out in the direction of course error (D), so that your deceleration burn also pushes you back in toward the Target. You would have to calculate the precise angle to orient your retroburn back inward . . . a pretty complex task.

Of course, the farther away your Target, the greater any retroburn error will be magnified by the time you reach that Target. This, of course, is why all spacecraft have powerful Autopilots that rely on computer-controlled navigation.

10. Monitor your Radial velocity readout very carefully. Sooner or later your deceleration burn will drop your velocity toward Mars to zero, then start thrusting you in the opposite direction, away from Mars. At that point, quickly cut your thrust.

This is an extremely complex and difficult maneuver, and the chances that your manual deceleration burn will stop you right at Mars (or even near Mars) are not particularly good. If you end up several million kilometers away from Mars, follow the directions in the nearby sidebar, "If You Overshoot or Undershoot Mars." Or you can just open your Flight menu, select Autopilot, set Mars as your destination, click on Rendezvous, then click on Execute. Bingo. You're there.

If You Undershoot or Overshoot Mars

Flying without using Autopilot is fun and exhilarating. But it is also notoriously inexact. There is a very good chance your deceleration burn will push you off course and slow your velocity to zero either well before or well after you reach the vicinity of Mars.

If this happens, you can reset the situation and try again, or you can do the following:

1. Immediately press F5 to cut your thrust.
2. Use pitch and yaw to zero in on Mars again.
3. Make a short-duration, full-thrust burn (press F8) to a modest velocity, then cut thrust again. (Sixty seconds of full thrust in your *F-79 Galactic Fighter* will raise your velocity to somewhere between 4 and 5 kilometers per second, depending on the strength and location of any gravitational forces in the vicinity.)
4. If you're more than a few thousand kilometers away from Mars, increase your Time Scale to speed up the remaining journey—but not too fast.
5. When you get within 20,000 kilometers of Mars, decrease your Time Scale to 1 sec/sec.
6. Keeping your Pitch at 000.00 degrees, yaw around 180 degrees until your F-79 is traveling tail-first again, then fire a full-thrust deceleration burn for about sixty seconds. Again, you need to keep a very close eye on your Radial Velocity readout. When it reaches zero, cut thrust immediately.
7. Now you're ready to proceed to step 4 of the mission, "Orbital Insertion."

Mission Step 4: Orbital Insertion

You are now ready for the fourth step of your mission, which is *orbital insertion*—that is, achieving a stable orbit around Mars. Again, try to do this without any help from the Autopilot. You will, however, use a handy navigation device known as a Head-Up display.

If the timing of your deceleration burn was good (or lucky), you should have slowed to zero velocity near Mars—within 100,000 kilometers or so. Now it's time to achieve a stable equatorial orbit around the red planet. To do this, you'll use both your Head-Up display and the Orbital Velocity Table that *Space Simulator* so kindly provides in the Help menu:

1. Click on your View 1 window to be sure it's active. Set View Location to Cockpit and View Direction to Panning. Then click on the Reset button to center the panning bars.
2. Select Show Head-Up Display from your Window menu.
3. Yaw your ship until you center the green 0 in the numbers at the top of the screen.
4. Pitch your ship until the middle of the dotted green line on the attitude grid (between the red 10-degree marker and blue 10-degree marker) crosses with the middle of the yellow line in the center of your window.
5. Now roll your ship until the yellow line lines up perfectly with the dotted green line.
6. You want to orbit Mars at a distance of 3 radii, so select Basic Skills from the Help menu, click on Spaceflight Skills, then click on the Orbital Velocity Table button.
7. You can either look in the table for the orbital velocity needed for a

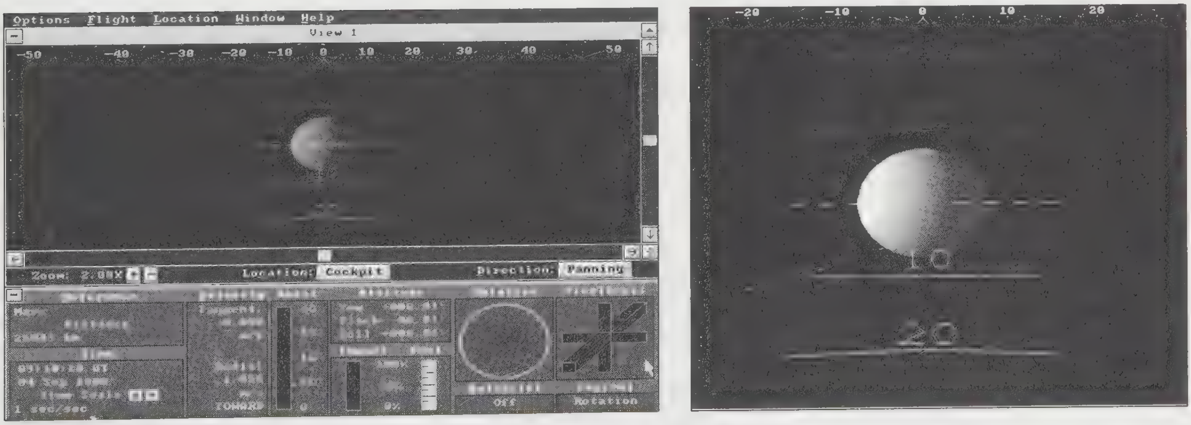
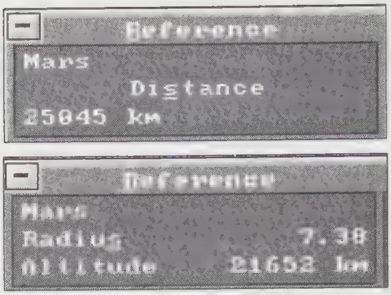


***Figure 5-16* Head-Up, Zeroed In.** *Here's what your Head-Up display will look like after you adjust Yaw, Pitch, and Roll to 000.00 degrees.* Left: *In this shot, you are locked on Mars, which sits 25,045 kilometers away.* Right: *A full screen view of the same shot.*



Reference
Mars
Distance
25845 km

Reference
Mars
Radius 7.38
Altitude 21652 km

Figure 5-17 Orbital Velocity Distance Readout. *Since the Orbital Velocity table only reports orbits in terms of radii, you need to click on your Distance readout* (top) *to toggle to a report of Radius and Altitude* (bottom).

3-radii orbit of Mars, or you can just keep reading this sentence because, after many clauses and commas and such, I will eventually tell you that the velocity you seek is 2.05 kilometers per second.

8. Click on Close.

Now comes an important little step. You'll notice that the Orbital Velocity Table only lists orbits in terms of radii. So you need your Distance readout to report how far you are from Mars in terms of radii, as well.

9. Click on the Distance readout on the instrument panel. The readout now reports your distance in terms of Radius and Altitude.
10. Apply thrust gingerly and approach Mars, keeping it zeroed in on your Head-Up display. Cut thrust after you reach a comfortable velocity—about 1 or 2 kilometers per second will work fine—and coast in.

Note: You'll notice your velocity gradually increasing even after you cut your thrust. This is Martian gravity pulling you in. Neat, eh?

This orbital attempt, by the way, easily qualifies as an advanced piloting maneuver. If you're one of those cocky rocket-jock types, continue on in Flight Control mode. If you're more pragmatic and don't feel your pride is at stake here, simply switch to the much easier mode of Slew Control.

Whatever mode you choose, you probably want to make some windowing adjustments to get a nice view of the action. Click on your Map View window and reduce the scale to 34,360 km. You might also want to change the View 2 window to Cockpit view in Tracking mode, and track Mars as you orbit. Or try something else. You're the captain, remember?

11. When you get to a Radius reading of about 3.1 or so, yaw left to -90.00

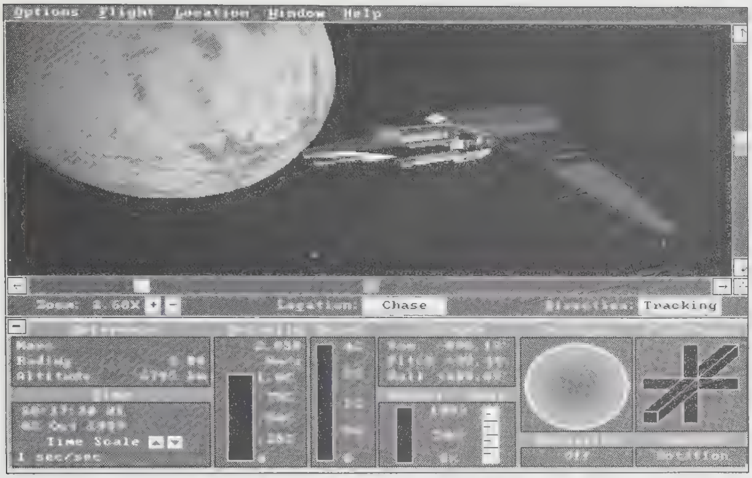


Figure 5-18 Mars Equatorial Orbit. *Radius reading of 3, yaw at about -90.00 degrees, velocity at 2.05 km/sec. Nice piloting, Tex.*

degrees or right to +90.00 degrees to position your ship for an equatorial orbit.

12. Sorry, slewers. If you want a stable orbit, you need gravity. Switch back to Flight Control if you're slewing.
13. Click on the Velocity readout to switch the display from the Radial and Tangential velocity display to your pure, unrelative Velocity display.
14. Fire full thrusters! (Press F8.) Remember, you need to reach your orbital velocity of 2.05 km/sec. Your *F-79* will build up speed quickly; cut thrust when you get close to 2.05 km/sec, then use your main engine thruster (Keypad +) to ease up to your orbital velocity.

Keep an eye on your Radius readout, too. You may need to yaw out away from the planet and increase your velocity a bit if you shoot past your 3-radii orbital distance.

Sooner or later, you'll manage to stabilize your orbit—probably later. Whenever you feel you've mastered this piloting skill, pause the simulation and move on to the next step of the mission plan.

Mission Step 5: Rendezvous and Docking

In this step of the mission, you'll use slew control, your fine thrust engines, and the *Mars Orbiter* docking port camera to complete your docking procedure with the silent space station. But first, let's rely on some good old-fashioned

Autopilot control to find the darned thing, which is circling Mars at an altitude of 3,389 kilometers above the surface.

1. Select Autopilot from the Flight menu, set Destination to the Mars Orbiter, and be sure to click on the Update boxes for both Reference Object and Tracking Object.
2. Click on the Rendezvous button and then click Execute.

   While Autopilot takes you to the Mars Orbiter, you should rearrange your windows for the upcoming docking procedure:
3. First, hide your Map View, if you haven't already.
4. Change View Location in the View 1 window to Chase Craft. (Be sure the tracking object is the *F-79*.)
5. Select View Controls from the Window menu, and click on the View 2 button at the top.
6. Change View Location to Assigned, then change Assigned View to the Mars Orbiter.

   Important: Click on the Docking Port Camera box under the Assigned View button.
7. Finally, change the View 2 tracking object to the *F-79 Galactic Fighter.* Click on OK.

Note: View 2 is now properly set up, but I suggest you keep it closed until your *F-79* is nearby and above the docking port. The Tracking view from the Docking Port Camera is confusing when the tracking Object is below the horizon of the docking port.

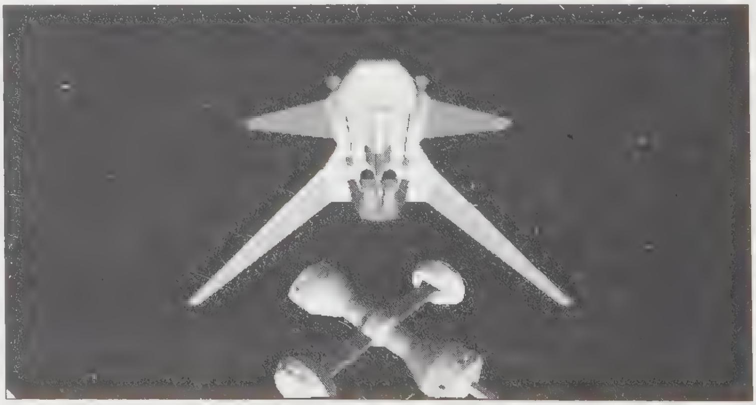


***Figure 5-19 Approaching the* Mars Orbiter.** *Your Autopilot deceleration burn will bring you in tail-first to the space station, so slide your View 1 panning bars around for a better look at your approach.*

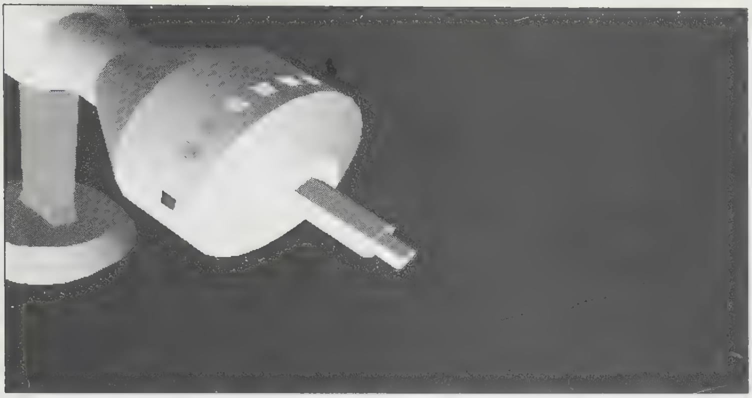


Figure 5-20 Begin Docking Procedure. *The orange hexagon at the end of that appendage is the docking port of the* Mars Orbiter. *Your piloting task is to mate it with the docking port on the underside of your* F-79.

Now you can actually watch your *F-79* maneuver up to the docking port through your View 2. Since the ship will probably approach the *Mars Orbiter* tail-first during a deceleration burn, you might want to slide your View 1 panning bars to see the approach.

Now it's time for some real flying. When Autopilot shuts off, you'll be left floating about 2 kilometers from the *Mars Orbiter.*

8. Switch your View 1 window to Cockpit view and yaw around to a 000.00 reading so you can see the *Mars Orbiter.* Can you see the orange tip of that appendage sticking out from the central axis? That's the docking port.

9. At this point it would be good to swallow your pride and switch to slew control. Apply gentle thrust and steer (pitch and yaw) toward the Orbiter's orange docking port.
10. When you close to within about 600 meters, roll your ship so that the *Orbiter*'s docking port is "below" you (see Figure 5-21). You will also be able to see the underbelly of your *F-79* now from the docking port camera in View 2; note your own docking port, which is also an orange hexagon.

At this point you want to set up your Chase view so that you can swing around your ship and check its alignment from all angles. (For a good example of this, see the short tutorial in the "Preparing to Dock" section of Chapter 8 in your *Star-Pilot's Guide.*)

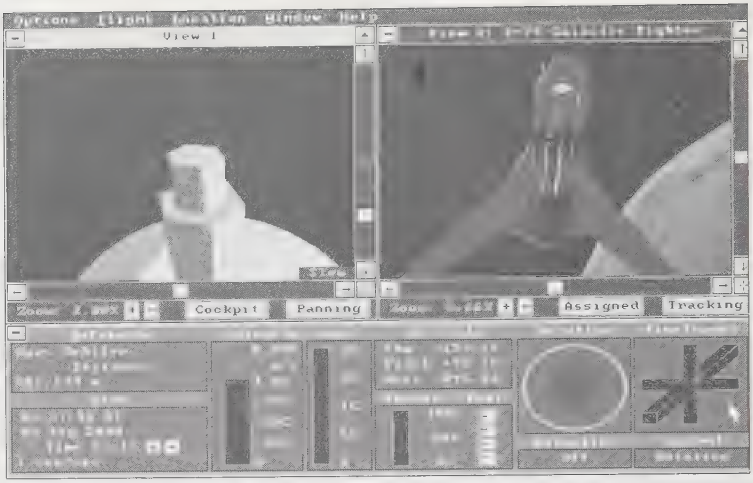


Figure 5-21 Only 556.134 Meters to Go. *Roll your ship's belly toward the* Orbiter*'s docking port for the final stages of your docking procedure. Note the dramatic view of your ship from the* Mars Orbiter *docking port camera in View 2.*

Here's how:

11. Switch your View 1 window to Chase view and Tracking. (Your tracking object should be the *F-79.*)
12. The idea is to see your ship in relation to the *Orbiter*'s docking port, so you want to be far enough away to see both. If the view is too close, select View Controls from the Window menu, click on View 1 and Chase Craft, then change your Chase Craft Perspective to about 5 and click OK.
13. Swing the view around your *F-79* by sliding the horizontal panning bar back and forth. Now you can switch to this view for perspective at various moments during your docking sequence.
14. Switch back to Cockpit view for now.

You're ready for final maneuvers. Here's where fine thrust comes into play. Remember that by using fine thrust, you can move your ship in any direction without altering its attitude. Since the docking port is often on the top or bottom of the spacecraft in the *Space Simulator* fleet, fine thrust becomes the only sure way to dock manually because you have to "raise" or "lower" your ship onto the target docking port.

15. Slide your View 1 vertical panning bar all the way down so that you're looking straight down from your ship's cockpit.
16. Apply fine thrust forward (Shift + Keypad +) until the *Orbiter*'s docking port is centered in your View 1 cockpit window.

17. For another alignment perspective, switch to Chase view and slide the vertical panning bar all the way up so that you're looking straight down on your ship from above, as shown in Figure 5-22.

Remember to keep an eye on the View 2 window as well. You'll see your ship from the perspective of the space station's docking port camera. This will help you line up your own docking port with the *Orbiter*'s port.

18. Now apply fine thrust down (Page Down) and keep a sharp eye on that Distance readout.

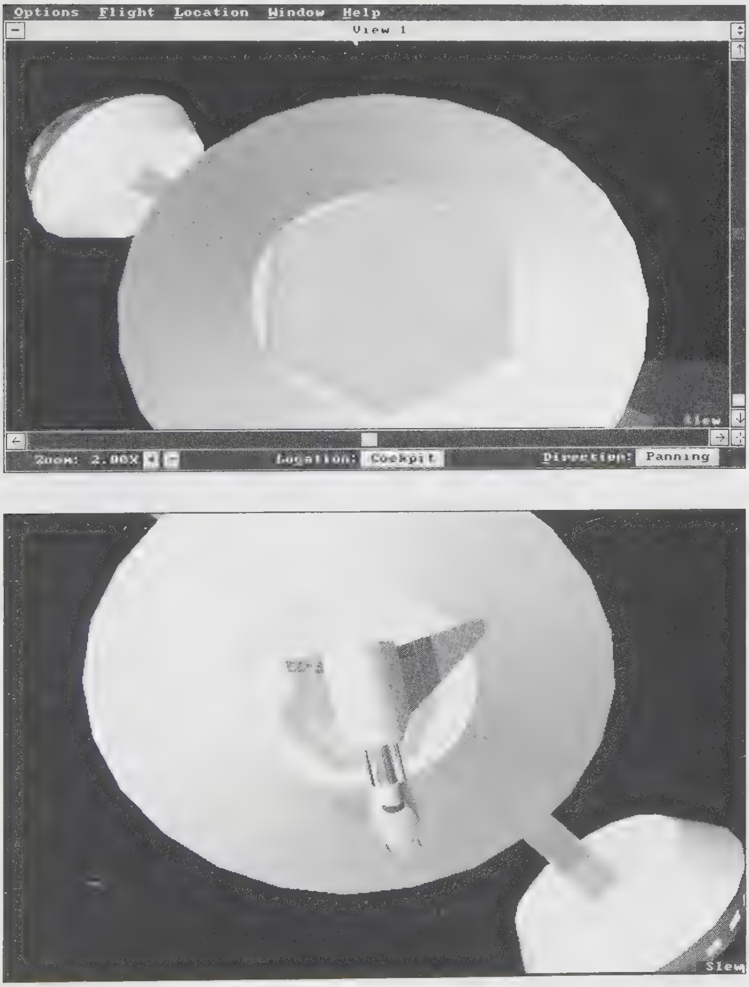
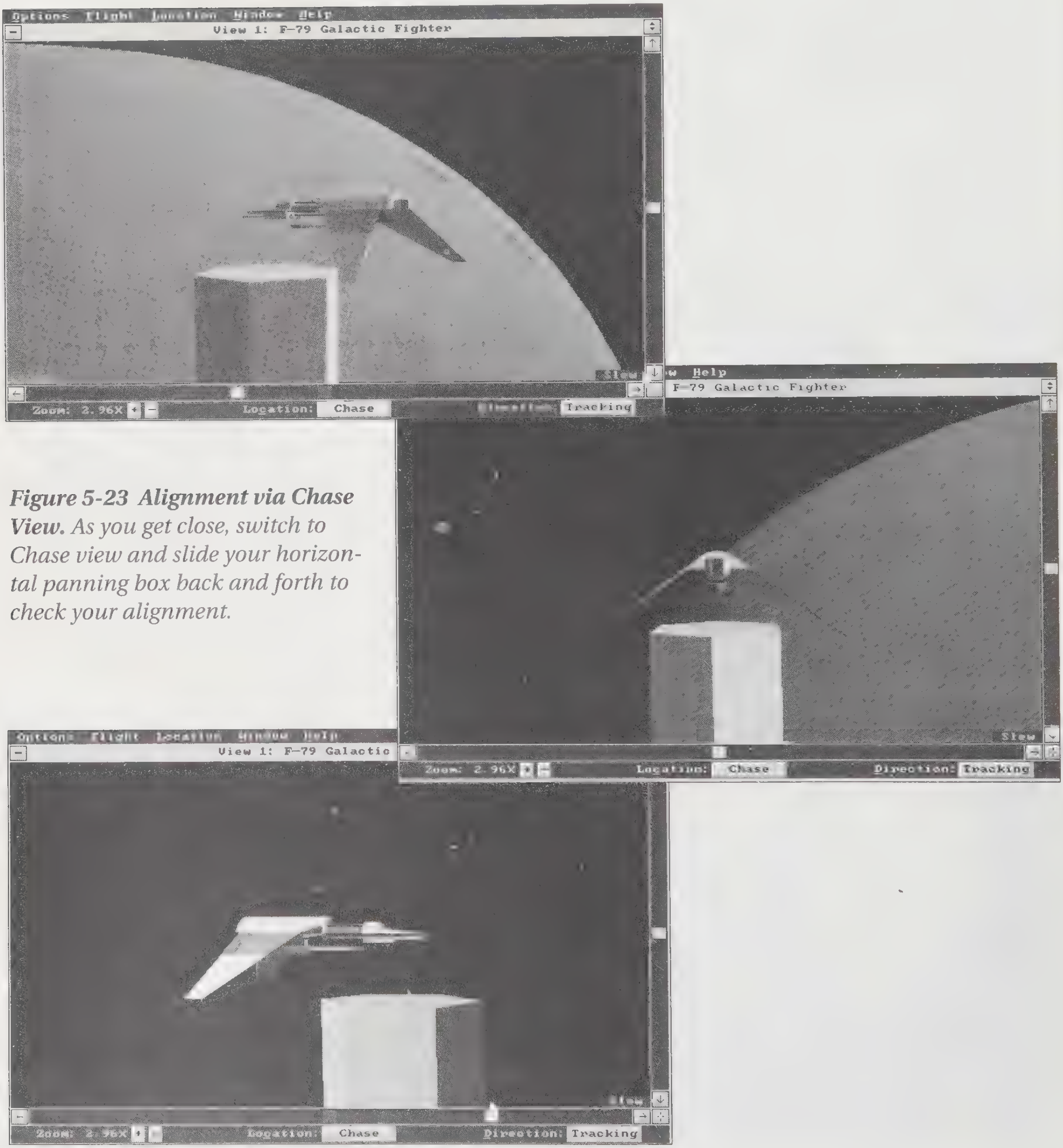

Options Flight Location Window Help
View 1
Slew
Zoom: 2.00X
Location: Cockpit
Direction: Panning
Slew

Figure 5-22 Ready to Mate: Two Views. *After fine-thrusting forward to this position, you're ready to lower onto the docking port.* Top: *Here's the view from your cockpit, looking straight down (slide vertical panning bar to the bottom).* Bottom: *This is a Chase view shot from above (slide vertical panning bar to the top).*

19. Stop when you get within 300 meters and switch to Chase view. Center the panning bars, then slide the horizontal box back and forth to get various perspectives of your alignment, as shown below.


Options Flight Location Window Help
View 1: F-79 Galactic Fighter
Slew

Zoom: 2.96X
Location: Chase
Direction: Tracking

Figure 5-23 Alignment via Chase View. *As you get close, switch to Chase view and slide your horizontal panning box back and forth to check your alignment.*

20. Keep applying fine thrust down, making attitude adjustments, and so forth, until you hear that wonderful click that indicates you've docked and locked into position. You'll also notice that your *F-79* has begun rotating with the space station.
21. Select Vehicle Transfer from the Flight menu.

Congratulations. You are now the ranking officer aboard the *Mars Orbiter*. But now . . . what mystery lies ahead?

Aboard the Orbiter

You decide to split your crew. Lieutenant Elkins, your copilot/navigator, remains on the *F-79*, keeping it flight-ready in case of an emergency. Specialist Meese joins you as you enter the airlock, then the space station.

The air in the *Mars Orbiter* is invigorating, freshened as it is by the greenhouse complexes in the polar hubs. Meese pores over a map—it's a massive facility, after all—and calls out hallways, elevators, and such. You keep your head up. No sign of anything out of order. No sign of anyone alive, either.

The two of you work your way to the Command Deck. Again, everything looks normal, operational. And again, no sign of the NASA advance team.

Suddenly, an odd physical sensation passes through you, like a weak electrical current.

Something is happening.

You barely have time to glance out the window of the Command Deck, where you see a hazy blue glow suddenly engulf the entire station.

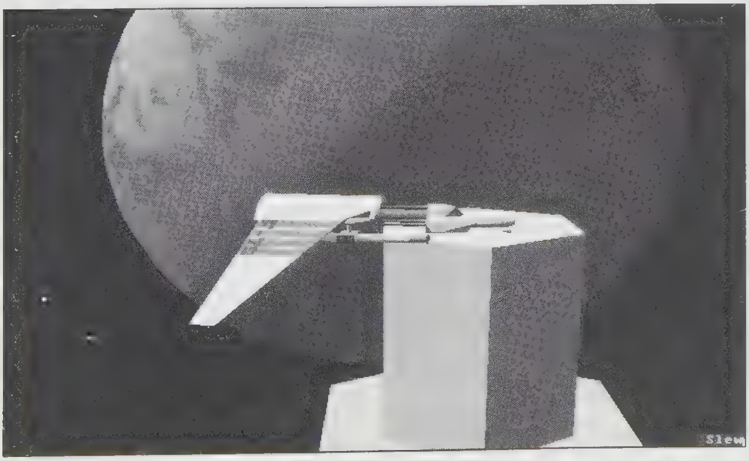


Figure 5-24 Locked On. *You did it! You're locked onto the* Orbiter, *with Mars shimmering in the background.*

22. Open the Location menu and select Stars. Choose Alpha Centauri from the file list and click OK.
23. Open the Location menu again, but this time select Moons. Choose Alpha Centauri II M1 from the file list. Be sure to check the Update boxes for Reference Object and Tracking Object, then click OK.

Mission Step 6: Warped!

The blue haze dissipates. You feel yourself rising up, weightless. You glance out the Command Deck windows again and see that the *Mars Orbiter* is no longer rotating—thus, no centrifugal force to simulate gravity.

The sky looks different. The sun is bigger.

What happened?

You order Specialist Meese to the central control bank. He pulls himself awkwardly forward, clutching at storage bin handles. Meanwhile, you kick off a nearby wall and float over to the Command Console.

After a short search, you find the attitude and thruster controls.

1. Press either one of the roll buttons (left or right) to get the *Mars Orbiter* rotating again.

As the roll slowly builds momentum, you feel the artificial gravity tug you slowly down into the captain's chair. You turn to a window and look out.

Here's what you see:

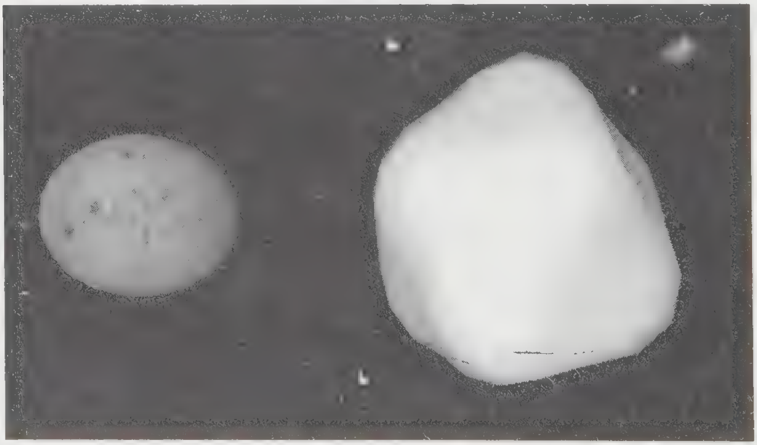


Figure 5-25 Post-Warp Cockpit View. *That planet sure resembles Mars, and that moon sure resembles Phobos. But even a cadet would know they're not Mars and Phobos. Welcome to the Alpha Centauri system.*

Specialist Meese clears his throat.

You turn to him. "Yes?"

"Captain." He looks bad. "Navigation systems are indicating something . . . anomalous." He gestures at the computer as if to suggest he had nothing to do with it. "They indicate we're no longer in the Solar System."

You nod toward the sun shining through the Command Deck window. "Then what is that, Meese?"

Meese stares at his console screen. He says, "Apparently, it's Alpha Centauri."

You stare at him.

He shrugs.

You say, "Alpha Centauri is 4.3 light-years from Mars."

Specialist Meese doesn't answer. You turn back to the window. For several minutes, you gaze out. Then you look down at the Command Console. You look at gauges. You are in orbit around the unknown moon of an unknown planet. You're the captain, you tell yourself. Do something.

So you adjust the viewing configuration for a close-range scanning orbit.

2. Arrange your view windows any way you want. My suggestion: Leave View 1 in Cockpit mode and set its tracking object to Alpha Centauri II. (You will only see the planets of the star system you are currently in.)
3. Put View 2 in Chase and Tracking modes, and change the tracking object to the *Mars Orbiter*. Also make sure Chase Craft Perspective is Absolute, so that only the Orbiter rotates rather than the whole picture.

One of the great joys of *Space Simulator* is cruising around in a space station. Wrestling a rotating behemoth across the cosmos is not unlike flying a 747. Except that while a 747 is a three-story building, your 1220-meter long, 300,000-metric-ton *Mars Orbiter* is more like the Sears Tower. Hey, how many people get to cruise around in the Sears Tower?

Let's get our space station into orbit around that red planet out there. Note that from this point on, you'll rely on Autopilot for maneuvers:

4. Select Autopilot from the Flight menu and click on Rendezvous.
5. Change the Destination to Alpha Centauri II, update the Reference Object and Tracking Object boxes, then click Execute.

Note: Sometimes the Autopilot will be too slow for you. You can also just switch to Slew Control and very quickly zoom in to about 14,000 kilometers above the surface of ACII.

6. When you arrive at AC II a couple minutes later, select Autopilot again and click on Orbit. Set your orbital radius to 2 radii above the surface, then click OK.
7. Click Execute to begin your orbit.

While you pilot, Specialist Meese runs a comprehensive scan of the Alpha Centauri system. You are looking at the second of eight planets. Alpha Centauri II resembles Mars in its ruddy color, well-cratered surface, and thin atmosphere.

Indeed, your close orbit of AC II reveals still more Martian-like features, including deep, canal-like rift valleys, towering mountain ranges, and an occasional volcano. Your instruments display its diameter to be about 7,247 kilometers, somewhat bigger than Mars. Its mass should give it enough gravity to hold in a substantial atmosphere, yet AC II shows no trace of water—no seas, no rivers, no signs of water erosion, not even a polar ice cap. Meese's sensor scans reveal no obvious indications of surface life.

But if there's no life here, who borrowed the *Mars Orbiter*?

And why?

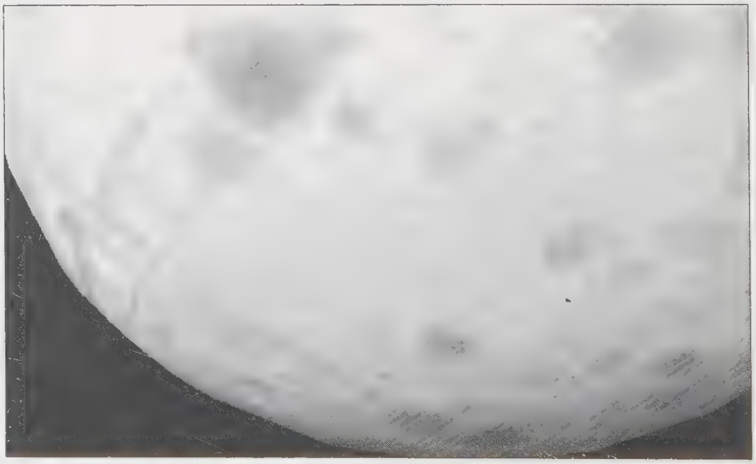


Figure 5-26 Close Orbit. *A closer look at Alpha Centauri II shows you a dead world very much like Mars—craters, rift canyons, and not a drop of water anywhere.*

As you muse on this, you find your thoughts going back to AC II's ghostly, odd-shaped moon. Interesting how closely it resembles the Martian moon Phobos. Like Phobos, it's quite small, with a diameter of only 380 kilometers. Also like Phobos, it orbits its mother planet at a relatively close distance—only about 36,000 miles, in fact.

Indeed, the resemblance to Phobos is so strong that you christen this moon "New Phobos" in your flight log. Perhaps the answer lies back there. After all, it was the reentry point from the space-time dislocation that got you here.

Perhaps there was a reason for this.

Mission Step 7: New Phobos Base

You quickly formulate your plan: Leave the *Mars Orbiter* behind, hop back to "New Phobos" in the *F-79*, land the fighter on the big white rock, and explore it with your MMU.

You and Meese reboard the *F-79 Galactic Fighter* and prepare to debark:

1. Select Vehicle Transfer from the Flight menu. You now control the *F-79* again.
2. Select Undock from the Flight menu.

Your rotation, which matches that of the space station, makes you appear to be docked still, but you are actually free to thrust away from the *Mars Orbiter.*

3. Select Autopilot from the Flight menu and click on the Rendezvous button.
4. Change your destination to Alpha Centauri II M1 and click OK.
5. Update the Reference Object and Tracking Object boxes, then click Execute.
6. You also might want to open your view controls and change the View 2 Chase Craft Perspective back to Relative.
7. When the Rendezvous maneuver ends, select Autopilot from the Flight menu again and click the Land button.
8. *Optional:* Watch your Altitude readout. When you get within 100 meters, press G to lower your landing gear. (If you don't lower the gear, the Autopilot will automatically do it.)

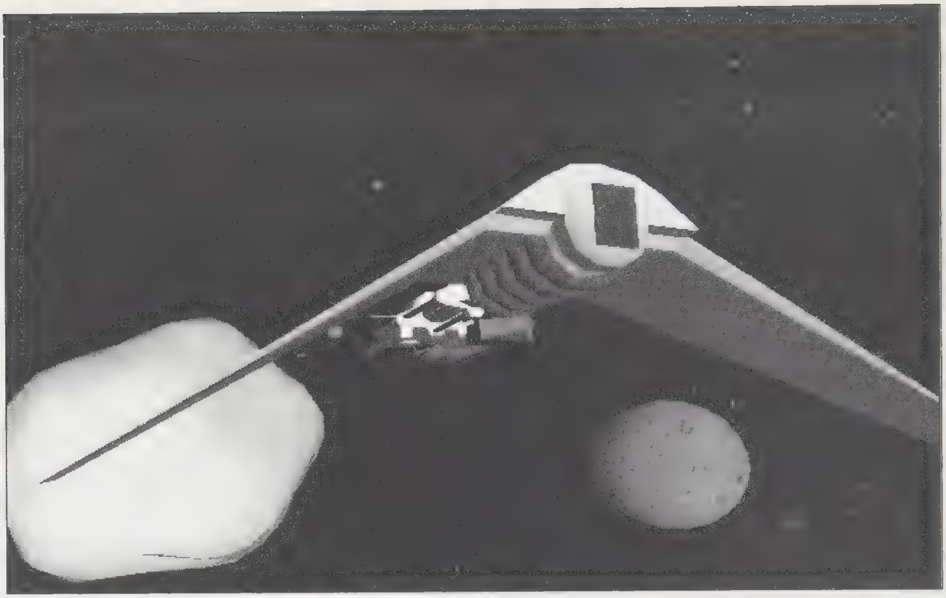


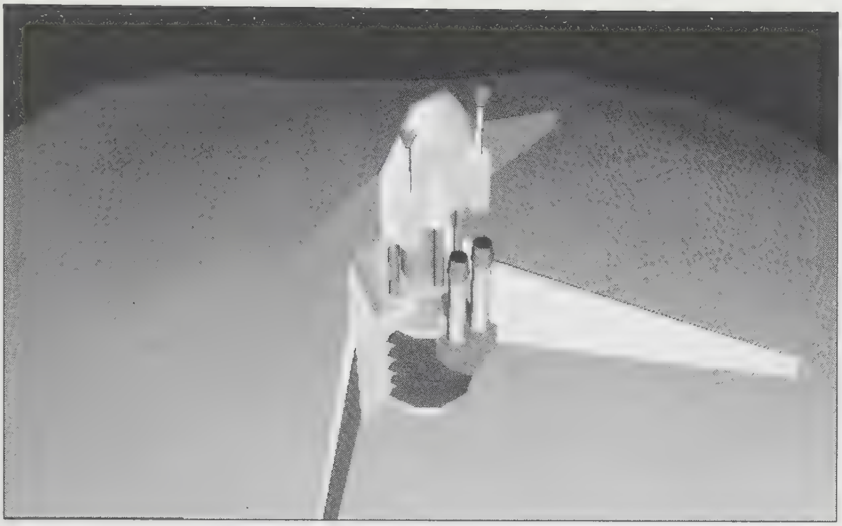
Figure 5-27 Approach to "New Phobos." *After your* F-79 *completes its rendezvous with Alpha Centauri II M1, fly around the moon to enjoy the panorama of a planetary system.*

As your ship slowly descends onto Alpha Centauri II M1, use the panning bars to swing around and get various views of the dramatic event.

Autopilot sets you down with a gentle bump. You and Lieutenant Elkins quickly prepare for EVA. Both of you pull on pressurized suits, then strap each other into your MMUs.

Note: Your so-called landing may not exactly *look* like a landing. It may depend on your machine, your Precision setting (under Preferences in the Options menu), or the balkiness of the simulation itself. My landing on Alpha Centauri II M1 left my *F-79* actually hovering in mid-air, and I was unable to get it closer.

You leave Specialist Meese behind in the ship. He'll monitor and map your progress, and keep an eye out ahead of you with his scanning sensors. Meese is a good man to have in the *F-79* in case anything gets funny, because he also happens to be your weapon systems expert.



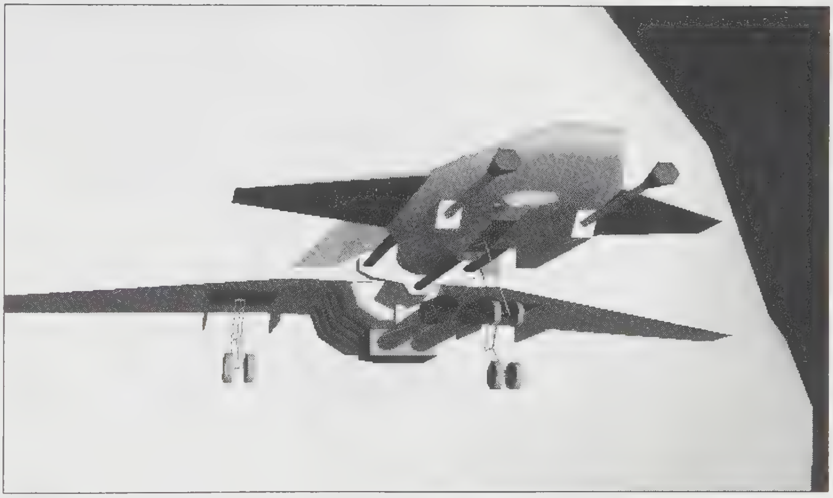


***Figure 5-28 Landing on "New Phobos."** As your F-79 backs into the smooth contours of New Phobos (Alpha Centauri II M1), pan around for some cool views of the landing sequence.* Above: *Perfect retrograde orientation means an efficient deceleration burn.* Right: *Press* G *to lower your landing gear.*

9. Select Space Walk from the Flight menu. If your View 2 is still in Chase view, you'll see yourself with your MMU emerge from the front of the *F-79*, moving about one meter per second.
10. Now have some fun exploring. Your MMU, of course, uses all of the same thruster controls as does any spacecraft.

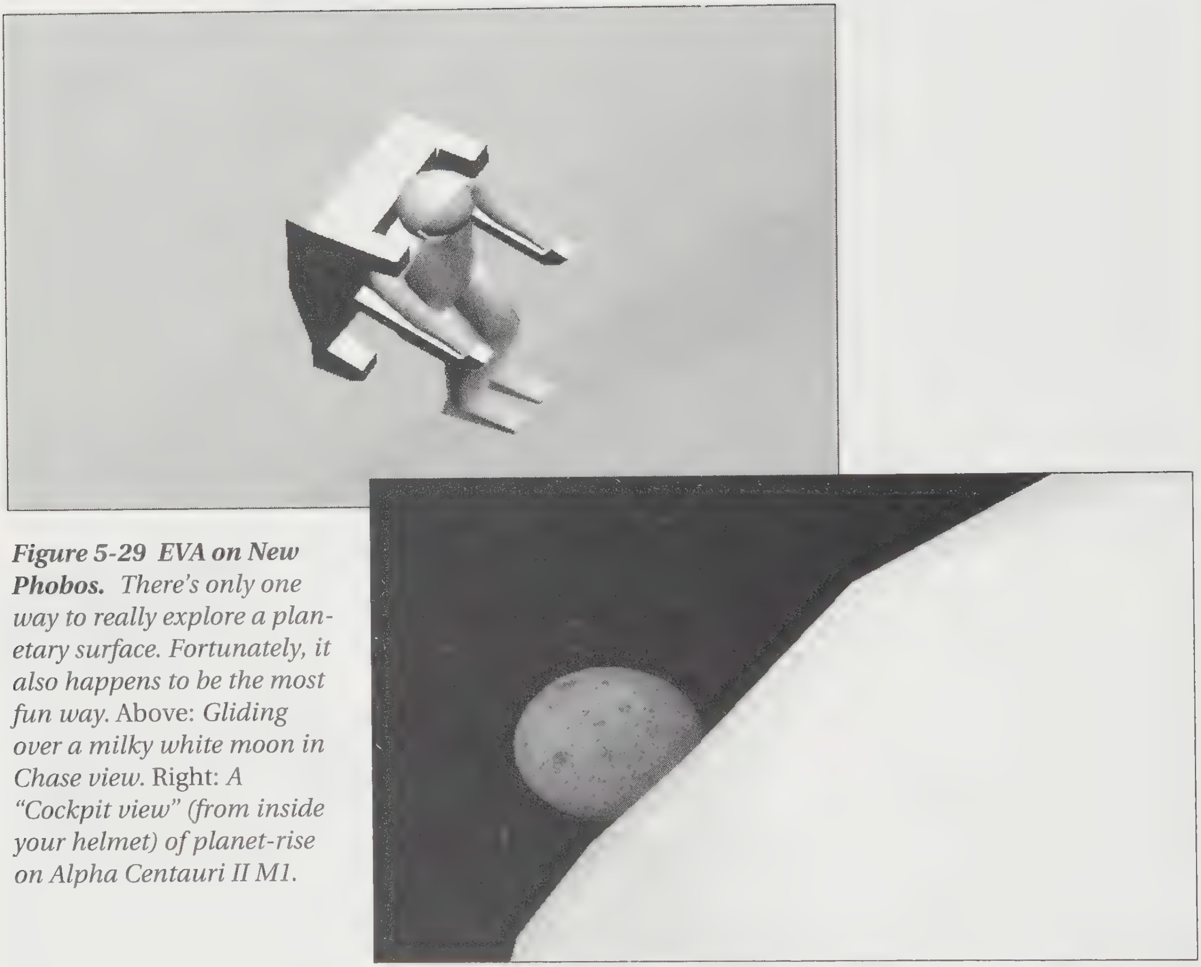


***Figure 5-29* EVA on New Phobos.** *There's only one way to really explore a planetary surface. Fortunately, it also happens to be the most fun way.* Above: *Gliding over a milky white moon in Chase view.* Right: *A "Cockpit view" (from inside your helmet) of planet-rise on Alpha Centauri II M1.*

You've always enjoyed the unfettered slalom of an MMU excursion, but there's tension in your voice as you chat with Elkins, who floats beside you, about this odd, polished white moon. The lack of cratering is unusual. Back on board the *F-79*, Meese reports a soil chemistry more suggestive of a rogue asteroid than a planetary moon.

Up ahead, just over a smooth ridge, you see a dark indentation in the milky white surface.

You look to your right. Elkins is already heading for it.

As you approach, you see it is a cave.

A Sordid, Horrifying Discovery

As you enter the cave, you are nearly sickened by the sight that greets your eyes.

You whistle and glance over at Elkins.

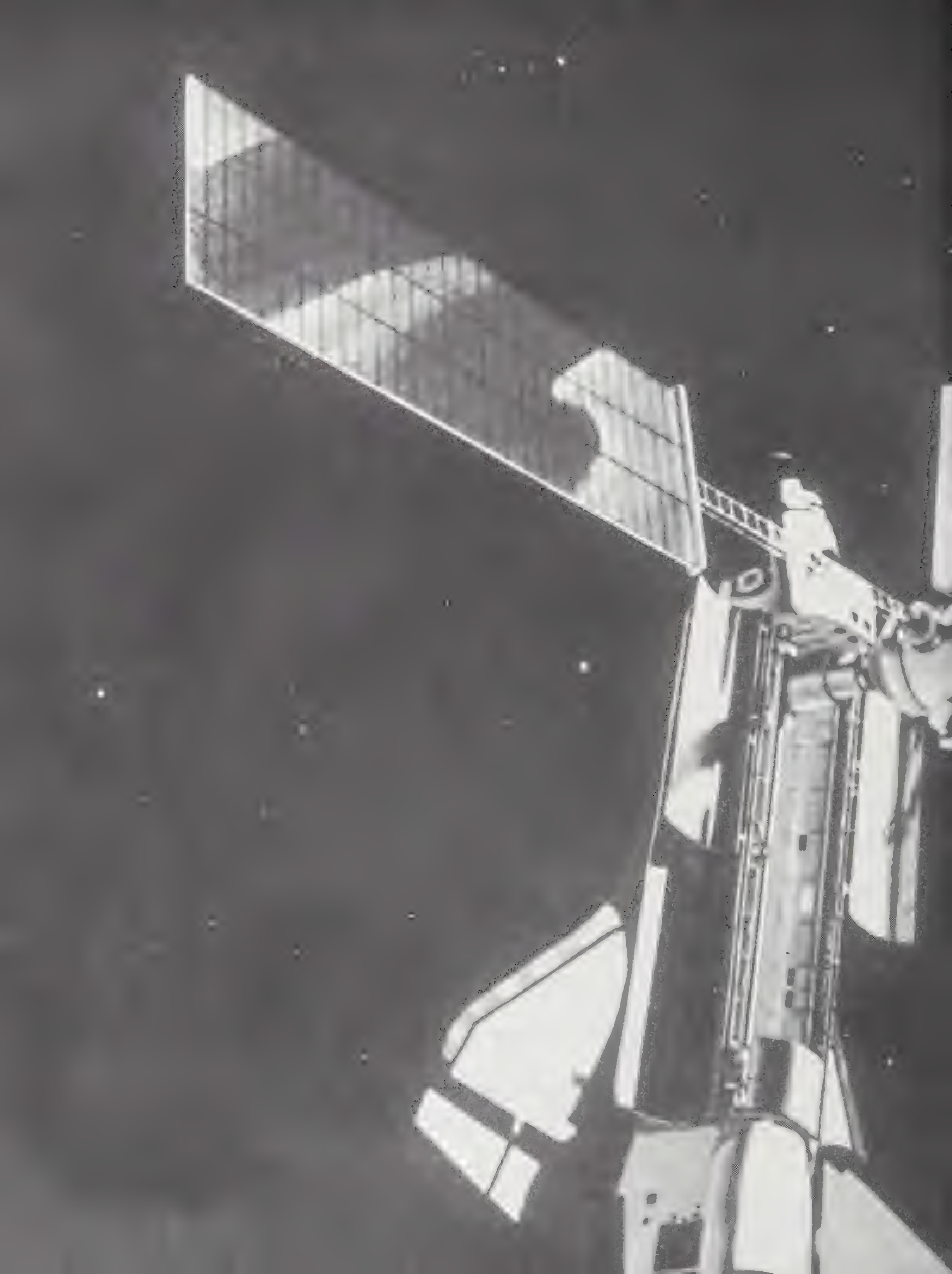
He gives you a grim look. You can see the light of recognition dawn through his visor. Yes. You both know what renegade life form inhabits this den.

Strewn about the cave like clean-picked bones are thousands of computer disks. Unauthorized copies of software—everything from *Word* and *Excel* to *Flight Sim 5.0* and countless Sierra adventure games. Piles of photocopied manuals and Prima strategy guides lay scattered around the enclosure.

You bitterly mouth the words: *Software pirates.*

"Good God," says Elkins.

You nod. It is a grisly discovery.



Chapter 6

Autopilot and Flight Computer

Mission: The Big Sling

This chapter reviews *Space Simulator*'s Autopilot and Flight Computer features. Then you'll use these to create a galactic adventure—a series of automated mini-missions connected by brief interludes of manual piloting.

Once again, you should read the sections on the Autopilot and Flight Computer in your *Star-Pilot's Guide* before attempting this mission. For your benefit, however, I've included a review of those functions.

AUTOPILOT

You've already used Autopilot quite a bit in previous chapters, which should give you an idea of just how indispensable a feature it truly is.

Note: Every Autopilot command can be stored for later use. Once you've selected the action you want, click on the Close button instead of the Execute button in the Autopilot dialog box. Then, when you're ready to use it, simply press Z to execute the stored Autopilot command.

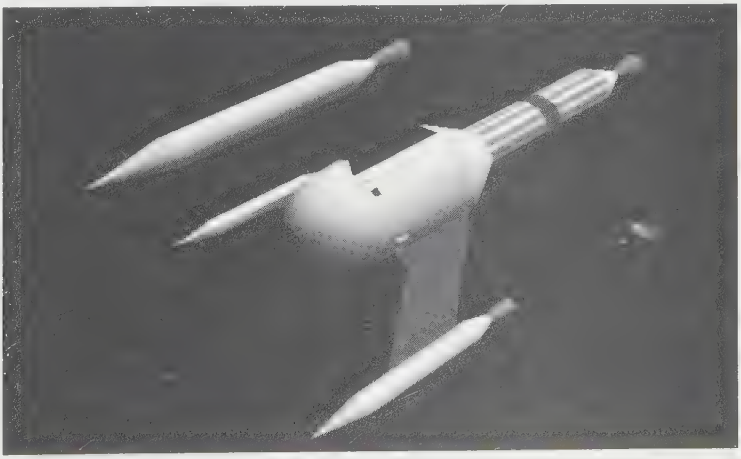
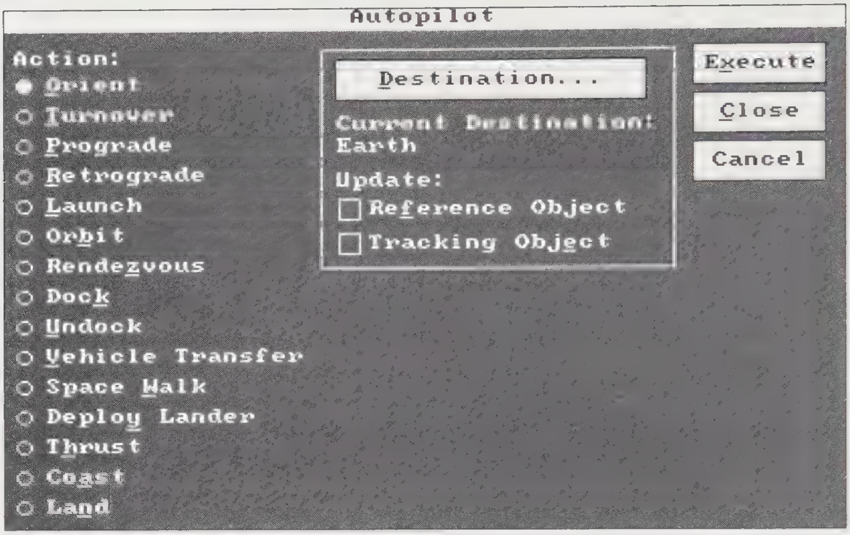


Figure 6-1 Mission Impossible? *Some astrophysicists think no human could ever see the core of the galaxy and live to describe the experience. Can the* Callisto *prove them wrong?*



Action:
● Orient
○ Turnover
○ Prograde
○ Retrograde
○ Launch
○ Orbit
○ Rendezvous
○ Dock
○ Undock
○ Vehicle Transfer
○ Space Walk
○ Deploy Lander
○ Thrust
○ Coast
○ Land

Current Destination:
Earth

Update:
☐ Reference Object
☐ Tracking Object

Figure 6-2 Autopilot. *To initiate any of the Autopilot actions, select Autopilot from the Flight menu, then click on the action that you want your computerized co-pilot to execute.*

Orient

The Orient command points the nose of your spacecraft directly at any object that you select. To orient your ship to a particular object:

1. Select Autopilot from the Flight menu.
2. Choose Orient from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Select the Object Type of the object toward which you'd like to orient your spacecraft.
5. Select the object from the list box, then click OK.
6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.

An important note on the Tracking Object "update" box: When you click on the Tracking Object box, your tracking object will be updated only for the current View Location of the currently active window. If you want your newly selected destination to be the tracking object for other View Locations or your other view window, you'll have to activate (click on) the window, select the desired view location, press T, then choose your new destination from the lists.

Remember that the view settings of each view window—View 1, View 2, and Map View—are independent of each other, and that you must change each one separately. This is a very liberating arrangement, but it can be very confusing at times too.

7. Click Execute.

Your spacecraft will now point itself at the destination object. If you also chose to update your reference object, your Pitch and Yaw readouts will now be 000.00. Note that the Orient command will not "zero in" your roll reading, however.

Turnover

Turnover yaws your spacecraft 180 degrees, pointing your ship in the exact opposite direction from which it was originally facing. To execute a turnover:

1. Select Autopilot from the Flight menu.
2. Choose Turnover from the Action list.
3. Click Execute.

Your spacecraft will now yaw 180 degrees to face the opposite direction.

Prograde/Retrograde

As your *Star-Pilot's Guide* points out, a prograde orientation points your spacecraft's nose in the direction of an established orbit. A retrograde orientation points your spacecraft's tail in the direction of an established orbit. To make a prograde/retrograde orientation:

1. Select Autopilot from the Flight menu.
2. Choose Prograde or Retrograde from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Select the Object Type of the object toward which you'd like to orient your spacecraft.
5. Select the object from the list box, then click OK.
6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.
7. Click Execute.

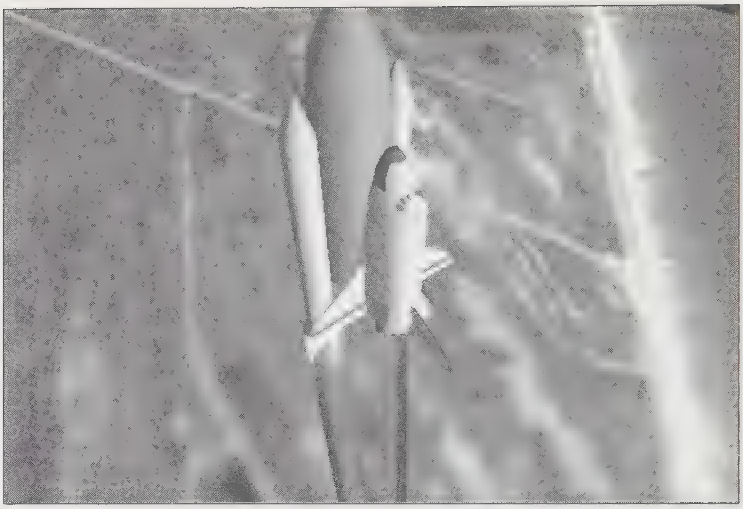


Figure 6-3 Autopilot Launch. *Begin your automated flight plan with a stunning launch sequence. The most dramatic autolaunch in* Space Simulator *is probably that of the space shuttle.*

Launch

The Launch action does exactly what it says—launches your spacecraft from the surface of a planet, moon, or other object. This automated launch sequence flies your ship to an orbital altitude that you select. You can also select a launch azimuth, which establishes the angle at which you'll orbit the object.

1. Select Autopilot from the Flight menu.
2. Choose Launch from the Action list.
3. Click the Orbital Radius button in the Autopilot dialog box.
4. Set the Altitude at where you'd like to orbit the object from which your ship is about to launch, then click OK.
5. Set Launch Azimuth (90 degrees is an equatorial orbit, 0 degrees is a polar orbit).
6. Click Execute.

Note: Your ship must be on the surface of some object in order for the Launch action to take effect.

Your spacecraft will now automatically launch and zoom into orbit at the prescribed angle around the planet, moon, or other object from which you launched.

Orbit

The Autopilot Orbit command lets you fly to any destination in the *Space Simulator* universe and enter a stable orbit. To use the Orbit feature:

1. Select Autopilot from the Flight menu.
2. Choose Orbit from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Select the Object Type of the object around which you'd like to establish a stable orbit.
5. Select the object from the list box, then click OK.
6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.
7. Click Execute.

Now sit back while your computer Autopilot flies you to your chosen destination and inserts your spaceship into a stable orbit around it.

Rendezvous

When you select Rendezvous from the Autopilot action list, you can fly to any destination in the *Space Simulator* universe, then match its position and velocity without orbiting it.

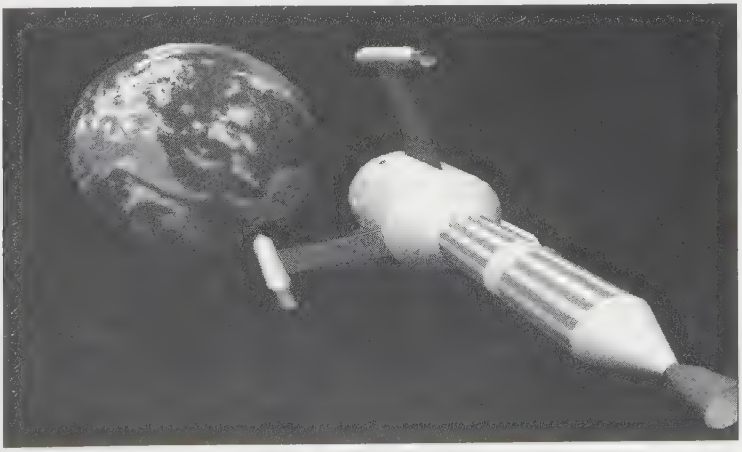


Figure 6-4 Rendezvous. *Use the Autopilot's Rendezvous command to travel directly to any object, then automatically match its position and velocity so that, in effect, you are hovering above its surface. Here's the* Callisto *after a rendezvous with Earth.*

To rendezvous with an object:

1. Select Autopilot from the Flight menu.
2. Choose Rendezvous from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Select the Object Type of the object with which you'd like to rendezvous.
5. Select the object you want from the list box, then click OK.
6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.
7. Click Execute.

Your Autopilot will now fly your ship to your chosen destination and place you in a stationary position at an optimal viewing distance. Remember, gravity may begin to pull you in as soon as you arrive.

Dock/Undock

Autopilot automates both the docking and undocking processes. Here's how to use them.

To dock:

1. Select Autopilot from the Flight menu.
2. Choose Dock from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Under the Object Type list, select either Space Stations or Spacecraft.
5. Select the station or ship to which you want to dock from the list box, then click OK.
6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.
7. Click Execute.

To undock:

1. Select Autopilot from the Flight menu.
2. Choose Undock from the Action list.
3. Click Execute, then apply thrust to move away.

Vehicle Transfer

This fun little feature lets you take control of the space station (or spacecraft) to which you've just docked. This does the same thing as the Vehicle Transfer command in the Flight menu. But since it's also listed as an Autopilot action, this action can be integrated into a flight plan using the Flight Computer (discussed in the next section).

Here's how to use it:

1. Select Autopilot from the Flight menu.
2. Choose Vehicle Transfer from the Action list.
3. Click Execute.

Now take that space station for a little spin around the galaxy.

Space Walk

With Space Walk you can take *Space Simulator*'s MMU (manned maneuvering unit) from your STS or LEM or ATL, or whatever NASA abbreviation you're flying, for an EVA (extra-vehicular activity) tour of the area.

Normally, you won't want to stray too far from the mother ship; you have only thirty minutes worth of fuel at full thrust.

The Space Walk action in Autopilot works the same way as the Space Walk command in the Flight menu. But with Autopilot, the action can be integrated into a flight plan using the Flight Computer (discussed in the next section).

Here's how to take a space walk:

1. Select Autopilot from the Flight menu.
2. Choose Space Walk from the Action list.
3. Click Execute.

Deploy Lander

The Deploy Lander action transfers your piloting controls to the ATL (all-terrain lander) and launches it from your current ship. This works the same way as the Deploy Lander command in the Flight menu, but with Autopilot, the action can be integrated into a flight plan using the Flight Computer (discussed in the next section).

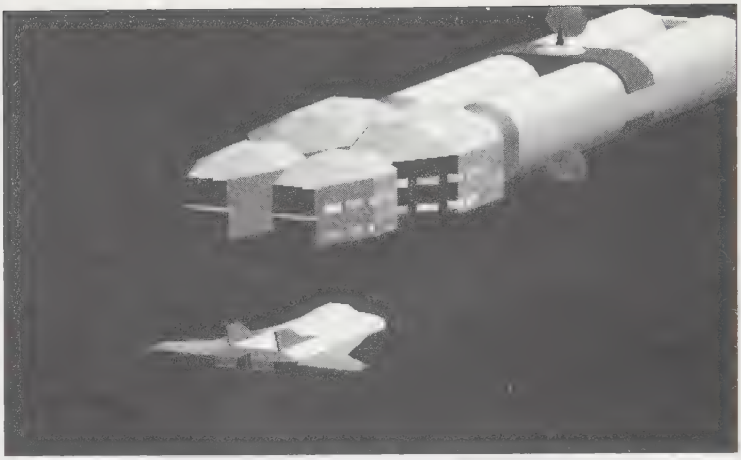


Figure 6-5 Deploy Lander. Here's your all-terrain lander (ATL), your best bet for planetary excursions, being deployed from the Galactic Explorer. *You can use your Autopilot's Deploy Lander command to include an ATL deployment as part of a preprogrammed flight plan.*

Note: By the way, once you deploy your All-Terrain Lander, you can select Spacecraft from the Flight menu and change the lander into any other spacecraft in *Space Simulator*'s fleet. Since your lander's mother ship remains part of the universe after deployment, you can do some interesting things. (See the tutorial on pages 200-201.)

To deploy your ATL:

1. Select Autopilot from the Flight menu.
2. Choose Deploy Lander from the Action list.
3. Click Execute.

Your ATL has only forty-five minutes of fuel at full thrust. So while the ship looks cool and interstellar, it's not, really. Limit its use to brief planetary excursions.

Thrust/Coast

The Thrust and Coast Autopilot actions let you set specific time periods of either full thrust or coasting without thrust in a flight plan. This is useful because you'll need to conserve fuel during long interstellar voyages. Remember, however, there are two way to refuel—dock at any space station and you'll be refueled automatically; or you can select Spacecraft Flight menu, choose your current spacecraft from the list, then click OK.

To set Thrust or Coast with Autopilot:

1. Select Autopilot from the Flight menu.
2. Choose Thrust or Coast from the Action list.
3. Click on the Duration button and type in the amount of time you want to thrust or coast.
4. Designate the unit of measurement you want—Seconds, Minutes, Hours, Days, Months, or Years—then click OK.
5. Click Execute.

Land

Simply select Land to have your Autopilot land your spacecraft at a destination that you designate.

1. Select Autopilot from the Flight menu.
2. Choose Land from the Action list.
3. Click the Destination button in the Autopilot dialog box.
4. Select the Object Type of the object on which you'd like to land your spacecraft.
5. Select the object from the file list, then click OK.

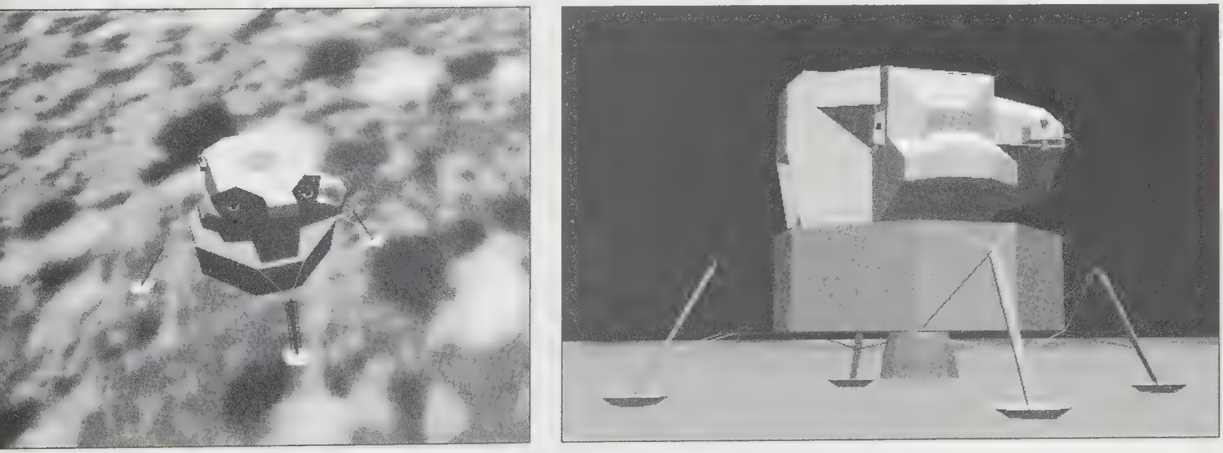


Figure 6-6 LEM Landing on Autopilot. *You can use the Land command to set your ship down on any surface. Here, the Autopilot guides the LEM (lunar excursion module) to a safe landing amongst the lunar craters.*

Hey . . . Go Orbit Yourself, Pal—

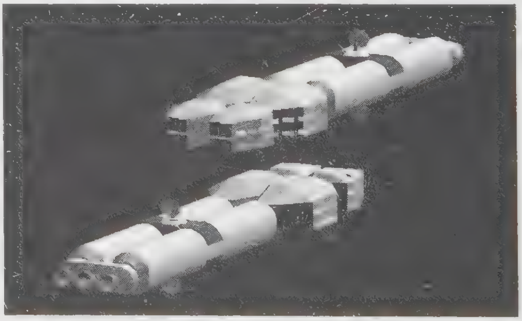
Here's something kind of interesting you can do to kill some time. (Well, it was interesting for me anyway.) With the Deploy Lander command, you can create a mini-armada of two *Galactic Explorer*s (or two of whatever your lander's mother ship happens to be) in the following manner:

1. Select Open Situation from the Options menu and choose FLIGHT from the file list. (If you're already in FLIGHT situation, select Reset Situation from the Options menu.)
2. Change your View 1 window to Chase view. Then be sure it's in Tracking mode; it should be already.
3. Slide the horizontal panning bar to the left so you have a side view of the ship.
4. Press Shift + D to deploy the All-Terrain Lander (ATL). Let it drop down from the *Galactic Explorer* until the mother ship disappears—about twenty seconds or so.

You are now in control of the ATL. All menu and window commands pertain to the lander. Yet the mother ship (*Galactic Explorer*) still exists in the situation. So let's double the fleet right now.

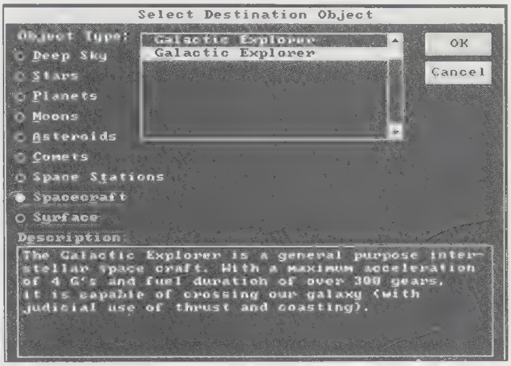
5. Select Spacecraft from the Flight menu and choose *Galactic Explorer*. The view should auto-adjust, giving you a shot of twin ships facing opposite directions.
6. Press T to change the tracking object.

You'll note that both *Galactic Explorer*s are listed in the file list. The second one is yours—the one that you mutated from an ATL into a *Galactic Explorer*. The first one is your mother ship.



Twins. *Change your just-deployed ATL into another* Galactic Explorer *to see a sight like this.*

7. Click on the first *Galactic Explorer* in the list box to make the mother ship your new tracking object. Click OK.
8. Now, just to be obnoxious, select Autopilot from the Flight menu and click on Orbit.
9. Click on the Destination button and choose Spacecraft from the Object Type list.
10. Click on the first *Galactic Explorer* in the file list, then click OK.
11. Click the Orbital Radius button. Type 2 in the Distance box and click the Radii button. Click OK, then Execute.



Select Destination Object

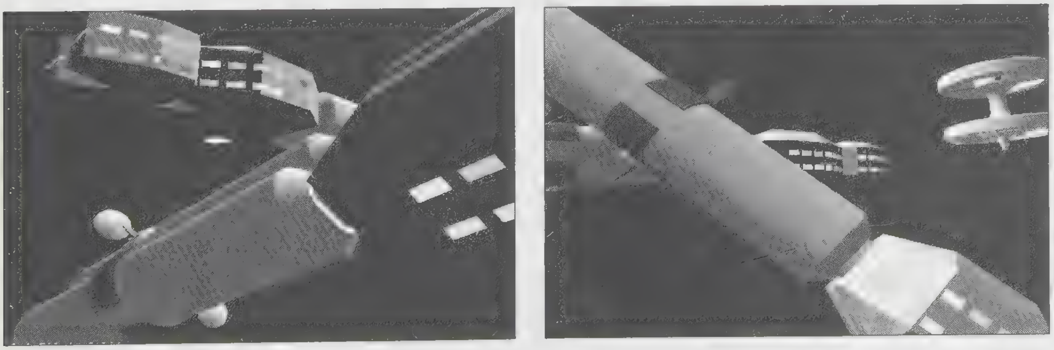
Object Type:
○ Deep Sky
○ Stars
○ Planets
○ Moons
○ Asteroids
○ Comets
○ Space Stations
● Spacecraft
○ Surface

Galactic Explorer
Galactic Explorer

Description:
The Galactic Explorer is a general purpose interstellar space craft. With a maximum acceleration of 4 G's and fuel duration of over 300 years, it is capable of crossing our galaxy (with judicial use of thrust and coasting).

Get Ready for the Mother of All Orbits. *Set the mother ship* Galactic Explorer *as your destination object. (The mother ship is the first* Galactic Explorer *in this list box. The second one, highlighted here, is your mutated "lander.")*

Now either zoom out or go into your view controls and move the chase craft distance farther away. Then enjoy the crazy sight of your *Galactic Explorer* offspring gyrating back and forth in a tight orbit around its mother ship "twin." Wow. What would Freud say about this?



Ring Around the Mother Ship. *Once the orbit begins, you can play with your view tools to get some really dramatic and/or weird shots, like these.*

6. If you want the new Destination to also be your Reference Object and/or the Tracking Object of the current View Location of the active window, click the corresponding Update box.
7. Click Execute.

Your spacecraft will now land itself on the destination object. It's a good idea to switch to Chase view (and make sure your ship is the tracking object) so you can watch your ship make its approach and touch down.

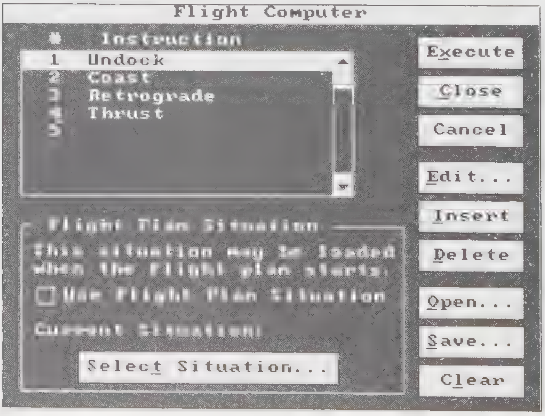
FLIGHT COMPUTER

Space Simulator's Flight Computer is a powerful tool. By linking a series of Autopilot commands in a sequence, you can create an automated flight plan that lets you sit back and really enjoy not only the cosmic beauty, but also the satisfaction of knowing just how resourceful you are.

If you haven't read Chapter 11 of your Microsoft *Star-Pilot's Guide*, I highly recommend that you do so now before moving into the mission sequences in this chapter. As with the rest of this book, I tried to design the mission to complement the excellent tutorials in *Space Simulator*'s documentation.

Create a Starting Situation

Generally, you'll want to have your automated flight plan begin at a particular starting point (called a situation) that you've created, or perhaps at one of the



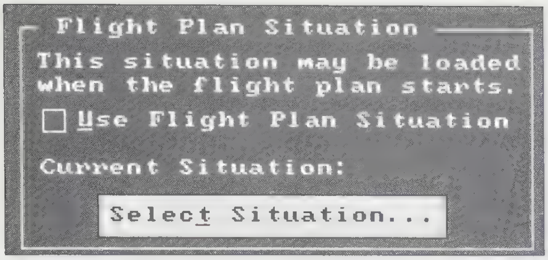
1 Undock
2 Coast
3 Retrograde
4 Thrust
5

This situation may be loaded when the flight plan starts:

☐ Use Flight Plan Situation

Current Situation:

Figure 6-7 Flight Computer. *Create an automated flight plan by linking a series of Autopilot actions with your Flight Computer. The flight plan in this shot is for a LEM deployment to the Moon.*



Flight Plan Situation

This situation may be loaded when the flight plan starts.

☐ Use Flight Plan Situation

Current Situation:

Figure 6-8 ***Starting Situation.*** *This section of the Flight Computer dialog box lets you choose any saved situation as the starting point of your automated flight plan.*

starting points already designed into *Space Simulator*. I haven't talked much about *Space Simulator* situations, assuming that you've read the manual and understand this very basic feature.

Remember that you can save your current situation at any time by simply selecting Save Situation from the Options menu, then typing a new file name into the box. Your saved situation is then added to the alphabetized list of files. Later, when you select Flight Computer from the Flight menu, you have the ability to choose one of these saved situations as the starting point of your automated flight plan.

To use a saved situation as the starting point for your flight plan:

1. Select Flight Computer from the Flight menu.
    - If you are creating a new flight plan, skip to step 4.
    - If you are adding or changing a startup situation to an existing flight plan, go to the next step.
2. Click on the Open button.
3. From the file list, select the flight plan to which you wish to add or change the startup situation, then click OK. You'll return to the Flight Computer dialog box.
4. Click on the Use Flight Plan Situation box.

The current situation is displayed below the box you just clicked. If you want to use the current situation as the starting point of your flight plan, continue on to the next section, "Create/Edit a Flight Plan." If not, move on to the next step.

5. Click on the Select Situation button at the bottom of the Flight Computer dialog box.
6. Select the situation you want from the file list, then click OK.

When you return to the Flight Computer dialog box, the situation you selected will appear as the current situation. Now you can move on to the next section.

Create/Edit a Flight Plan

Creating a sophisticated flight plan is remarkably easy, thanks to the wide range of Autopilot commands at your disposal. Editing a flight plan is equally easy. You'll create a number of flight plans in this chapter's mission tutorial, so I'll be brief here.

To create a flight plan:

1. Select Flight Computer from the Flight menu. You'll see an Instruction list box, empty except for a highlighted line with the number 1 at the top.
2. Click on the Edit button to add the first instruction. The Instruction #1 dialog box appears.
3. Select the Autopilot action you desire for the first maneuver of your flight plan.

Each Autopilot action will have its own set of specifications. These may include selecting a destination, duration, orbital radius, orbital inclination, and so on.

Note: Setting specifications for any Autopilot action in a flight plan works in exactly the same way as it does when you choose that action directly from Autopilot in the Flight menu. To see how to set these specifications, then, check out the "Autopilot" section earlier in this chapter.

4. Set any required specifications for the Autopilot action you selected, then click OK. You'll return to the Instruction list, and your selection appears on line 1.

Note: The highlighted line in the Instruction box is always the currently active line. Whatever command you choose—Edit, Insert, or Delete—will be applied to the highlighted instruction line.

5. Continue to add instructions, line by line, in the same manner as described above for line 1. Remember that you can delete or edit

existing instructions. Just highlight the line you wish to alter and click the appropriate command button.

6. When you are finished with your flight plan, click the Save button, type a name (less than eight characters) for the saved plan in the File Name box. Click OK.

You now have a saved flight plan. To execute the plan, click the Execute button. Or store it for later use by clicking the Close button.

To execute a stored flight plan: Open the Flight Computer from the Flight menu—the stored plan will be listed in the Instruction list—then simply click on the Execute button or press Z key.

To edit an existing flight plan:

1. Select Flight Computer from the Flight menu, then click on the Open button.
2. In the list box, highlight the flight plan you wish to edit and click OK.
3. Highlight any instruction you wish to change and click the Edit button.
4. Choose a new Autopilot action in the usual manner (setting its specifications, and so forth), then click OK. The new instruction will appear in place of the one you previously highlighted.
5. When you're finished editing flight plan instructions, click on the Save button and save your edited plan. (If you feel a gnawing ambivalence about overwriting the old plan, just type in a new name.)

MISSION: THE BIG SLING

Your discovery of the New Phobos software piracy ring and their wormhole warp detector earns you a promotion to the rank of commander. A mixed blessing—more respect, more pressure. Well, it could be worse. You remember flight school.

Your new starship is a Hornet-class cruiser christened the *Independence*. Your first run on the tub takes you around Jupiter. Looking out at the billowing gas giant, you think about Oates, an old friend of yours from college. Guy made captain, got a regular fleet assignment. One day he took a slingshot of Jupiter a little too close. You think about Oates every time you swing through the Jovian system. You figure whatever's left of him down there weighs 646.8 pounds.

Gravity doesn't discriminate. You smile grimly, remembering the words of

Major Barnes, your first flight instructor. *It pulls down the best with the worst.*

Thank God it's such a constant. Your new 9000 Series flight computer would never let you "pull an Oates," which is what the kids in flight school call a G-dive these days. Or would it?

The *Independence*, it turns out, is badly in need of some drive work. You end up at Cape Canaveral, sitting like a lump behind a desk. Somebody throws paperwork in front of you. You look through it, toss it aside.

You play 36 holes of golf, drink dinner, and go to bed.

The next day, however, you're rousted at 0600 by an annoyingly chipper ensign. The kid says you're scheduled for a shuttle run from Canaveral up to *Space Station Freedom*. Orders are to catch a *Zander Freighter* out to Callisto, in the Jovian system. At this, your eyes finally open.

Callisto. You've heard rumors.

Word has it Fleet Science made some kind of find near Callisto. Nobody wants to go public, though. Lot of whispering and sideways glances in the hall.

You stroll from your quarters to fleet HQ. Boyd Elkins waits for you at the security elevator. They made him a captain, so you made him your chief of staff. Specialist Meese is still with you too, manning his beloved computers. He's waiting to be picked up at Mars Base Marineris.

"Any word yet, sir?" says Elkins.

"Nada."

Elkins watches the floor numbers rise. Then he says, "Nice day, though."

"Oh yeah," you say.

After a stonewalling session that they call a "preliminary briefing," you and Elkins are none the wiser. You're taxied out to Pad 39B, the venerable launching site of three generations of space shuttles. You watch Elkins crack his knuckles nervously as you ride the service tower lift up to Level 195. There, you cross a steel-grated catwalk to the sterile white Ready Room that abuts the hatch of the orbiter.

After what seems an endless wait, technicians in ghostly coveralls, caps, and booties enter. They help you into your escape harness. Nobody speaks. The technicians finish, then methodically load you aboard.

Elkins gives you a look as he's strapped into his seat. Like a guy in the electric chair, you find yourself thinking.

You wonder what lies ahead.

What have they got up there on Callisto that has everybody acting so damned spooky?

Mission Step 1: Canaveral to Freedom

Let's start with a few Autopilot commands, just to get the hang of things. The goal is to follow this little narrative and get to *Space Station Freedom*, where you can hop a *Zander Freighter* to your destination. First, initiate a shuttle launch from Cape Canaveral, rising to an orbital altitude of 200 kilometers. (As you know from your *Star-Pilot's Guide*, this matches the orbital altitude of *Space Station Freedom*.)

Unfortunately, limitations in *Space Simulator* will not allow you to rendezvous and dock with *Space Station Freedom* from the launch situation. But that's OK. You can just open another situation and continue from there.

1. Select Open Situation from the Options menu.
2. Choose situation PAD-39B from the file list, then click OK.

Note that situation "PAD-39B" is a full-screen view which places the space shuttle on Launch Pad 39B at Cape Canaveral, ready for liftoff.

3. Now click on the very top-left of the screen, then select Autopilot from the Flight menu.
4. Select Launch from the Action list. Leave Launch Azimuth at 90.00 degrees, which puts you in an equatorial orbit.
5. Click the Orbital Radius button.
6. Type 200 into the Altitude box, and be sure it's set for kilometers.
7. Remember to click the Altitude above Surface button. Then click OK.
8. Click the Execute button in the Autopilot dialog box.

Figure 6-9 Shuttle Launch. *It doesn't get any more glorious than this. This first leg of your Chapter 6 mission gets you acquainted with your Autopilot Launch feature.*

Now sit back and watch the full screen fireworks. Once you've established a stable orbit 200 kilometers up, it's time to set up your rendezvous with the space station. If you read about *Space Station Freedom* in your product documentation, you know it can only be visited via the "1999" situation or various "SHTDOCK" situations. So let's start there:

9. Select Open Situation from the Options menu.
10. Choose SHTDOCK3 from the file list, then click OK.

The SHTDOCK3 situation will put you in a space shuttle that is already configured for docking with *Space Station Freedom.*

Note: For more challenge, you can try docking manually at this point. But hey, God made Autopilots for a reason. Don't feel bad about using them.

11. Quickly select Autopilot from the Flight menu.
12. Under Action, choose Dock, then click on the Destination button.
13. Under Object Type, choose Space Stations. The only station available to this situation is Space Station Freedom. Click OK.
14. Click Execute.
15. After you've docked, select Spacecraft from the Flight menu.
16. Choose Zander Freighter, then click OK.
17. Change your View 1 window to Chase view so you can see the massive ship docked with the space station.

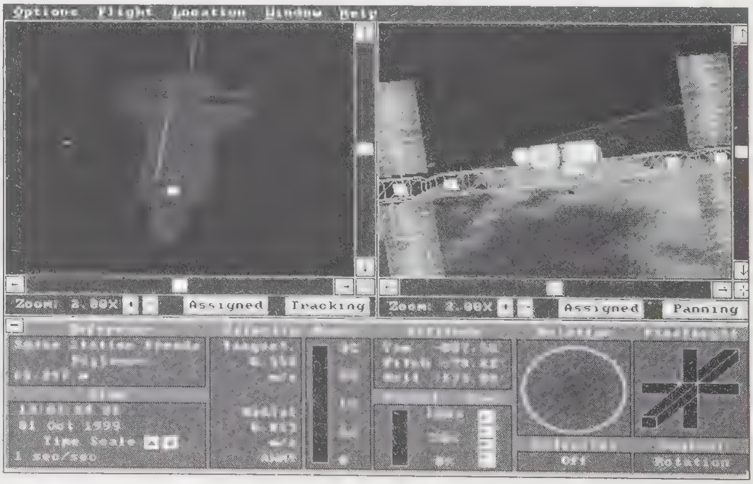


Figure 6-10 ***SHTDOCK3.*** *This situation is one of the few in* Space Simulator *that can put you in touch with* Space Station Freedom. *You'll start with your shuttle nicely positioned for Autopilot docking.*

18. Select View Controls from the Window menu and change Chase Craft Distance to 2.

Note: You may still find it hard to see *Space Station Freedom,* which now looks like a dragonfly caught in the mouth of some huge beast. You'll have to zoom in quite a bit—at least 10.5X or so—in order to get a decent look at both. (See figure 6-11.)

19. Select Show Window Titles from the Window menu to bring back the Maximize buttons, then maximize View 1.
20. Select Save Situation from the Options menu. Type in a new file name—I suggest MARS-RUN—then click OK.

You're now stowed aboard your interim ship, a *Zander Freighter.* Time to move on toward your appointed destination, the Jovian moon Callisto. But first, you'll need to make a quick stop at Mars Base Marineris. The freighter is scheduled to make a cargo drop, and you need to pick up Specialist Meese.

Mission Step 2: Mars Base Marineris

The *Zander Freighter* is huge. It's . . . well, *bigger* than huge. You could play full-court basketball on the bridge. And for a freighter, it's what a real estate salesman would call "lavishly appointed": oak-paneled quarters, spiral staircases, brass fixtures in the bathrooms. It's almost obscene.

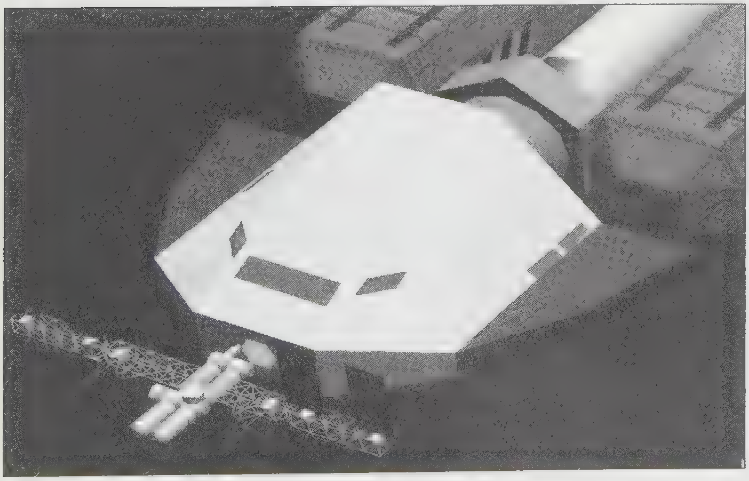


Figure 6-11 Docked and Ready. *After you dock your shuttle with* Space Station Freedom *and switch to the* Zander Freighter, *you're ready to move on to the next step of the mission.*

Even more impressive, though, is the freighter's astonishing charged-particle propulsion system, capable of kicking 100,000 metric tons of ship forward at an acceleration of 2 g's. Good thing all the recent advances in g-resistance technology let you open the throttle without simultaneously deconstructing your body.

Authors Note: Don't ask me what these "g-resistance advances" could possibly be. Nobody—not even Stephen Hawking—fully understands the essential nature of gravitational force in the universe yet.

However, we do understand the effect of gravitational force on the human body, and if you read "Human Physiology in Space" in Chapter 2 of this book, you know how little tolerance we have for g-forces much beyond 1g. Yet for some reason, Space Simulator's Autopilot initiates full thrust—whether accelerating or decelerating—for much of the journey.

For example: If you travel to Achernar in the F-79 Galactic Fighter, you spend a good portion of the trip thrusting at 8-g accelerations! At 8 g's, you'd be slouching around with ten or twelve hundred pounds of sluglike body mass. (Multiply your body weight times eight.) How long do you suppose you could handle that?

Hence, this book's science fiction assumes some sort of futuristic gravity-neutralizer: It's important to keep your internal organs from migrating down into your lower extremities.

The freighter captain is a nice enough fellow—Irish, happy, doesn't mind that you outrank him. His name's Fallon. You tell him how much you despise sitting at a desk. He grins and suggests you take the ATL down to pick up Meese when you arrive at Mars.

* * *

OK, enough fiction. Time for a Flight Computer tutorial. Let's create an automated sequence to get the massive freighter undocked and off to Mars. Then you'll deploy the all-terrain lander and set down at Mars Base Marineris—one of the coolest places in the program.

Let's start by directing the Flight Computer to load a starting situation for the flight plan:

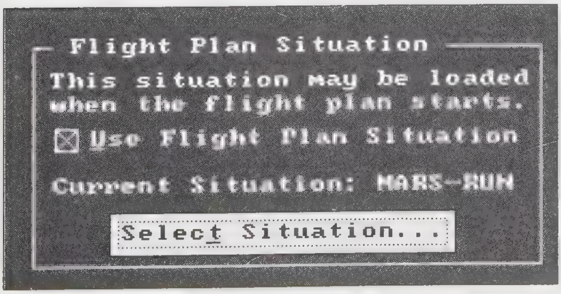
1. Select Flight Computer from the Flight menu.
2. If there is anything in the Flight Computer's Instruction list, click Clear and then OK to delete all instructions.
3. Click to put an X in the Use Flight Plan Situation box.
4. Click on the Select Situation button.
5. Choose MARS-RUN from the file list and click OK.

If you came to this step directly from Mission Step 1, you are already in the MARS-RUN situation, since you never left it. But load it into the flight plan anyway, just to see how this particular feature works.

6. Click Edit and select Undock from the Action list.
7. Click OK. Undock now appears as Instruction #1 of the flight plan.
8. Be sure line 2 in the Instruction list box is highlighted.

Note: Remember, the highlighted line in the Instruction list is the active line. Any edit or deletion you perform will apply to the highlighted line. Insert adds a line just before the highlighted line

9. Click Edit and select Rendezvous from the Action list.
10. Click the Destination button, then select Planets from the Object Type list and choose Mars from the file list. Click OK.
11. Click on the box to update your reference object, then click OK.
12. Highlight line 3 and click Edit.



This situation may be loaded when the flight plan starts.

☒ Use Flight Plan Situation

Current Situation: MARS-RUN

Figure 6-12 Starting Situation: MARS-RUN. *This section of the Flight Computer dialog box lets you choose any saved situation as the starting point of your automated flight plan.*

13. Select Deploy Lander from the Action list, then click OK.
14. Highlight line 4 and click Edit.
15. Select Land from the Action list and click the Destination button.
16. Under Object Type, select Surface. Then choose Mars Base Marineris from the file list. (You'll probably have to use the scroll bar at the far right of the box.) Click OK.
17. Be sure there's an X in the Reference Object box under Update, then click OK.
18. Highlight line 5 and click Edit.

Remember, Commander, you're picking up Specialist Meese, your computer expert. He's waiting patiently, but let's give him a few seconds to hop aboard.

19. Under Action, select Coast.
20. Click the Duration button, type 30 in the box, then click on Seconds. Click OK.
21. Your Event Duration should now read "30 seconds." If so, click OK.

This is sort of misleading, because you won't really "coast." In fact, you will just sit there. When a spacecraft is on the ground—that is, when its Altitude readout displays the word "Landed"—it can't move anywhere laterally until it thrusts back up into the air or is launched with the Autopilot. This use of the Coast action is just a way to give Specialist Meese thirty seconds to dive aboard.

22. Highlight line 6 and click Edit.
23. Select Launch from the Action list and click the Orbital Radius button. (You can leave Launch Azimuth alone.)
24. The settings may already be in place: Type 300 in the Altitude box, click Altitude above Surface, click Kilometers, then click OK.
25. Click OK again.
26. Highlight line 7 and click Edit.
27. Under Action, select Rendezvous, then click the Destination button.
28. Under Object Type, select Spacecraft. Choose the Zander Freighter from the list box, then click OK.
29. Again, update the reference object by putting an X in the box, then click OK.
30. Highlight line 8 and click Edit.

31. Under Action, select Dock, then click the Destination button.
32. The Destination should already be set to Zander Freighter. If so, just click OK.
33. Hurry, click Save, before all this work gets zapped out by a lightning strike or something. Type a name for your flight plan into the File Name box—again, I suggest MARS-RUN—then click OK.
34. Now click Execute to set your grand design in motion.

Don't just sit back and watch this time, though. You should do some window work to get a good view of the multifarious action. For example:

35. First of all, you should zoom out to about 3.11X so you can see the entire *Zander Freighter*. You might need to pan around a bit to get it centered in your view window.
36. Select View Controls from the Window menu and change Chase Craft Perspective to Absolute.
37. While the *Zander Freighter* travels to Mars, you might want to select Show Instrument Panel from the Window menu or Press the I key so you can monitor distance to the red planet.
38. You can also select Show View 2 from the Window menu, then:
    - Switch View 2 to Cockpit and Tracking views.
    - Press T and change the View 2 tracking object to Mars.

This way you can watch Mars grow closer as you approach it. Of course, you may just want to maximize View 1 and enjoy the spectacle of the majestic *Zander Freighter* maneuvering toward Mars.

When the freighter's Rendezvous action is complete and the ATL deploys, watch it land at *Mars Base Marineris*, sit for thirty seconds, then blast off back into the sky to rendezvous and re-dock with its mother ship.

Mission Step 3: The *Callisto* Mystery

When you first saw Specialist Meese bounding madly over the Martian terrain in a pressure suit, you could tell he had news. In the ATL pressure airlock, he nearly ripped off his helmet too soon. You had to bark a reminder about the unpleasant nature of explosive decompression.

When he finally got inside, his eyes were bursting with his knowledge.

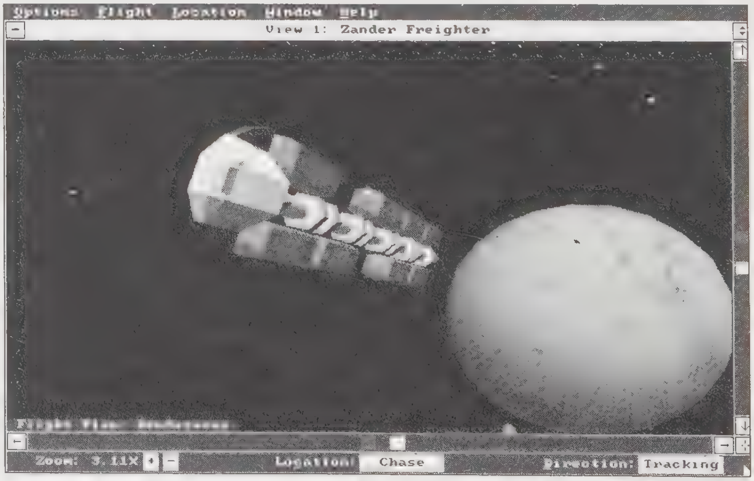
"It's Callisto," he blurts. "I know why we're going."

Important Reminder About Panning/Tracking in Chase View

Remember, when you slide the panning bars around to change the camera view, the camera movement is different for Tracking and Panning modes. Here's a review:

- In **Chase/Tracking mode**, your camera swings around your designated tracking object—in this case, your *Zander Freighter*—like a ball on a string.
- In **Chase/Panning mode**, on the other hand, your camera is set at a fixed point in relation to the tracking object, then swivels in any direction. Note that you can change the camera's fixed point, however, by switching to Tracking mode, swinging around to another perspective of the tracking object, then switching back to Panning mode.

You might want to try the brief Panning/Tracking tutorial in Chapter 4 of this book. It walks you through a series of camera movements illustrating the differences between Chase/Tracking and Chase/Panning.



View 1: Zander Freighter

Zoom: 3.11X

Location: Chase

Direction: Tracking

Figure 6-13 View 1:* Zander Freighter *at 3.11X Zoom. *Here's your* Zander Freighter *decelerating into its rendezvous with Mars. Don't be afraid to play around with the panning bars or switch back and forth between Tracking and Panning modes to get dramatic views of the action.*

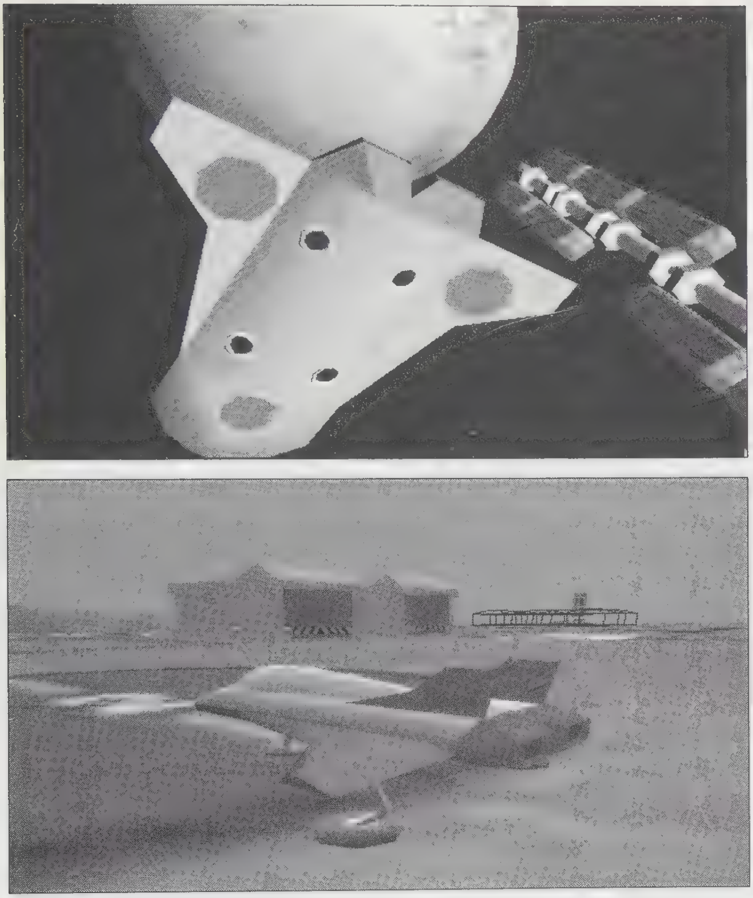


Figure 6-14 **_Quick Pickup._** Top: *If you programmed your Flight Computer properly, your ATL will automatically deploy away from your* Zander Freighter *and descend to* Mars Base Marineris. Bottom: *The ATL sits "coasting" (unmoving, actually) for thirty seconds at the base, then rockets back up to its mother ship.*

Meese is the son of a retired vice admiral. He has connections at Fleet HQ. It seems he has connections everywhere. Friends who know things. Deep sources.

You ask, "So . . . what is it?"

His eyes dart around. "They found something in orbit," he says.

Elkins leans over. "What, an old probe? Didn't they lose a *Magellan* out here somewhere?"

Specialist Meese turns to him. "It's not a probe," he says.

"An asteroid," grins Elkins. "A quasar. A quark?"

Meese shakes his head.

He says, "A *starship.*"

* * *

First, let's quickly get the *Zander Freighter* to the moon Callisto. Then you'll set up a fun multiple-ship adventure that will test your Flight Computer's mettle. As part of that adventure, you'll board the mysterious *Callisto* starship:

1. Select Autopilot from the Flight menu.
2. Under Action, select Rendezvous and click the Destination button.
3. Under Object Type, select Moons, then choose Callisto from the list box and click OK.
4. Put an X in the Reference Object box under Update.
5. Click Execute.
6. When the Rendezvous action stops, press End or F8 to apply full thrust in any direction away from Callisto.
7. Initiate a full roll in either direction, left or right.
8. Continue full thrust until the freighter accelerates up to about 10km/s, then press F5 to cut thrust. (If you're impatient, you can increase the Time Scale to get the freighter moving.)

Note: Be sure you've cut your thrust before attempting the next instruction! (Otherwise you'll crash, if you're not in Practice skill level.)

9. With the freighter still rolling, select Deploy Lander from the Flight menu.
10. Select Spacecraft from the Flight menu.
11. Highlight Callisto and click OK. You are now aboard the exotic alien spacecraft.
12. Thrust away from the rolling *Zander Freighter* in any direction for a few seconds.
13. Select Save Situation from the Options menu, then type in a name for this new situation—I suggest BIGSLING—and click OK.

* * *

The three of you sit on the bridge of the *Callisto* in a triangular arrangement of flight seats—ergonomically designed, quite comfortable. Specialist Meese

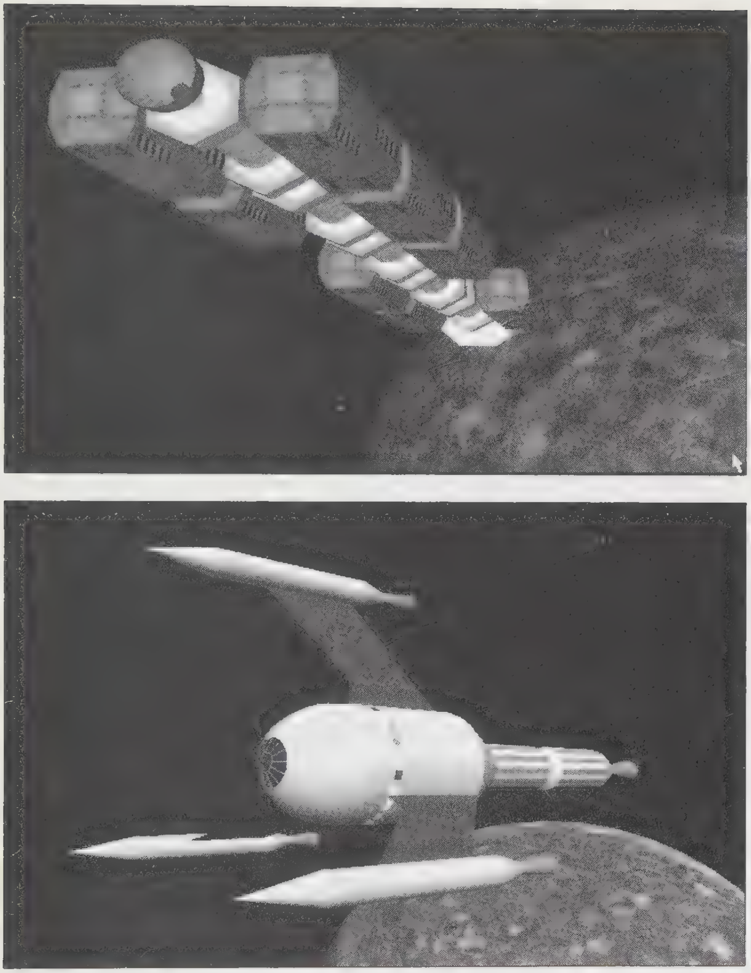


Figure 6-15 Tricky Transfer. Top: *Your* Zander Freighter *arrives at Callisto, ready to be sent rolling away.* Bottom: *After you deploy your ATL and craftily switch to the* Callisto *using the Spacecraft command in the Flight menu, you're ready for a daring multi-ship rescue mission.*

blinks, staring at the alien flight console. Computers. He wants at them, bad. Elkins seems obsessed by the bulkhead.

You've never seen anything like it.

It's beautiful. Uncanny. Elegant. The hull looks like burnished steel, yet when you touch it, it's soft, crinkling like a sheet of Mylar.

Origin unknown.

Purpose unknown.

Dr. Bernard Blassner, the stone-faced director of Fleet Space Sciences Division, briefs you on the ship's propulsion and navigation systems. He explains that a flight plan seems to be preloaded into the Flight Computer. Initial orientation is *coreward*, into the heart of the galaxy. After that, nobody knows. When Blassner's done, you sit in shocked silence.

After a moment, Specialist Meese raises his hand.

"This isn't a schoolroom, son," says Dr. Blassner.

Meese stands like a student anyway. He says, "Synthetic gravity? How can that be?"

Blassner shrugs.

"What's the hull material?"

"We don't know yet."

"It's soft," says Captain Elkins suddenly, loudly.

Dr. Blassner manages a tight smile. "Don't worry," he says. "It'll take a bullet."

Elkins reaches out to the nearby bulkhead. He pokes it.

"Actually, it'll take a cannon shot," says Blassner. "This stuff makes our best alloys look like cheesecloth."

Elkins considers that for a moment. Then he says, "How fast can this rig run?"

You grin at him. The guy's a pilot, after all.

Dr. Blassner looks perturbed. He's a man who's accustomed to having answers. He says, "That's why you're here, Captain Elkins. To find out."

There is an uncomfortable silence. Abruptly, you stand. Everybody looks at you. You want to take Dr. Blassner for a little walk, and ask a few hundred questions. You want to examine specs, readouts, lab results. You want to debate the nature of this apparent invitation.

Instead, you clear your throat and say: "OK. Let's do it."

Mission Step 4: Rescue!

Before you have a chance to make more gruff, John Wayne-style pronouncements, a junior officer nearly falls through the hatch of the *Callisto*.

"We've got an emergency situation," he says.

"What is it, Lieutenant?" says Dr. Blassner.

"The *Zander Freighter*, sir. We think it took a meteor hit. We're getting no response from the bridge, and our scan readouts indicate she's rolling wild."

You and Elkins exchange glances. Then he moves to *Callisto*'s flight console.

After a quick perusal, he says: "Yeah, I can do this."

* * *

Let's rescue the rolling freighter. Actually, let's have the Flight Computer do it. (Don't worry, you'll still get the credit.) You also need to simulate an alien higher intelligence. (Hey, you can do anything with *Space Simulator.*) You'll program the *Callisto*'s flight computer to give the three human passengers the ultimate galactic thrill ride.

1. Select Flight Computer from the Flight menu and click Clear to delete all instructions.
2. Put an X in the Use Flight Plan Situation box, then click on Select Situation.
3. Choose BIGSLING from the list box and click OK.
4. Click Edit.
5. Under Action, choose Dock and click the Destination button.
6. Under Object Type, choose Spacecraft, then select Zander Freighter from the list box and click OK.
7. Under Update, put an X in the Reference Object box. Click OK.
8. Highlight line 2 and click Edit.
9. Under Action, choose Vehicle Transfer. (This will transfer control to the *Zander Freighter.*) Click OK.
10. Highlight line 3 and click Edit.
11. Under Action, choose Orient, then click the Destination button.
12. Under Object Type, select Moons, then choose Callisto from the list box.
13. Under Update, put an X in the Reference Object box. Click OK.
14. Highlight line 4 and click Edit.
15. Under Action, choose Vehicle Transfer. (This will transfer your control back to the *Callisto.*) Click OK.
16. Highlight line 5 and click Edit.
17. Under Action, select Undock and click OK.
18. Highlight line 6 and click Edit.
19. Under Action, choose Rendezvous, then click the Destination button.
20. Under Object Type, choose Deep Sky. Select Galactic Core from the list box and click OK.

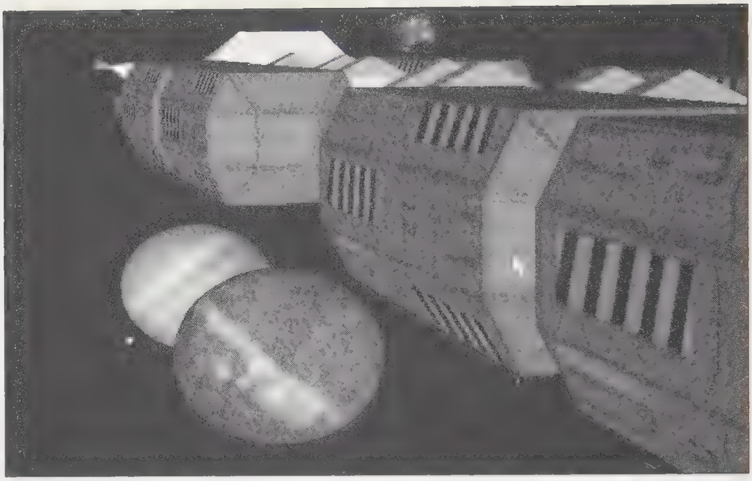


Figure 6-16* *Beauty Shot.
After you dock, transfer aboard the Zander Freighter *and get it oriented toward Callisto. You might see a Chase view beauty shot like this one—freighter, moon, Jupiter, all in a line. (Actually, I pitched the ship up a bit to frame the shot better.)*

21. Under Update, put an X in the Reference Object box. Click OK.
22. Highlight line 7 and click Edit.
23. Under Action, select Orbit. Leave the Current Destination at the Galactic Core.
24. Change the Orbital Inclination to 0 degrees for a polar orbit.
25. Click the Orbital Radius button.
26. Type 700 in the Altitude box. Be sure (and I mean this) that you also click the Million Kilometers box and the Altitude above Surface box. (This may seem like a wide orbit, but believe me, with a black hole, it's not.)
27. Click OK twice.
28. Click Save and select BIGSLING from the file list. Click OK.
29. Click Close to store the flight plan.

You'll see the pulse-pounding drama unfold in a minute, including the daring rescue and the joyride preprogrammed into *Callisto*'s alien flight computer.

Mission Step 5: Downhill Racer

Your rescue of the *Zander Freighter* was fairly routine, it turns out.

The meteor strike nearly severed one of the massive modular cargo bins, but no living quarters appear damaged. The shot came from directly above, causing a clean rolling action that was relatively easy for *Callisto* to match. If any pitch or yaw had been added to the spin, the docking maneuver would have been hell, even for an advanced alien Flight Computer.

As the airlock hissed open, you rushed aboard to the sight of Captain Fallon's legs protruding from the bridge garbage chute. He was unconscious, pinned into the chute by the centrifugal force of the freighter's spin.

Aside from a nasty lump, he'll be OK.

Elkins pulled his way to the flight console and got the ship oriented back to Callisto Moon Base.

So you've done your good deed for the day. Back on the *Callisto*, it's time for your moment of truth.

"This is entirely voluntary," you say. "You know that, don't you?"

Meese and Elkins both nod.

In front of your command chair, on a small podium, a red button blinks. It is inscribed with an odd marking. Dr. Blassner said that NASA managed a partial decryption of alien markings. Here's the proof: Next to the button, a small piece of masking tape has the word "Execute" scrawled on it. An arrow points to the button. You find this amusing.

You glance over at Elkins. He looks at the button, then at you.

"Nice day, though," he says.

"Oh yeah," you say.

You look at Meese, who raises an eyebrow. And then you push the button.

* * *

1. Select Flight Computer from the Flight menu.
2. Your BIGSLING flight plan should be loaded and ready to run. If it isn't, click the Open button, select BIGSLING from the file list, and click OK.
3. Click Execute.

A Note About Your Windows: As you may have noticed, I've now turned you loose to create your own viewing angles of this adventure. Remember that *Space Simulator* lets you manipulate your view controls when the simulation is paused—a truly great design feature. So hit that Pause key repeatedly and shift the view around.

* * *

Callisto's slumbering graviton drive awakens. The Autopilot kicks in.

"Holy cow," says Elkins.

You look at him. He's gone pale. You follow his gaze out the flight deck window and see the moon Callisto recede in the distance with stunning alacrity. It looks like someone hit a baseball out of the park.

Clearly, this is superluminal velocity. It seems like you're hurtling out of control and yet, there is a feeling of well-being. A pleasing sensation. Like the silver hum of a Porsche cruising in sixth gear.

Meese is plastered to the window. "Star fields are moving out there" he says. He turns to you like an eager puppy. "Gosh, they're moving."

"This is incredible," says Elkins.

Ahead, the dense center of the galaxy seems to literally drift apart before your eyes. And then, a bright orange swirl gradually emerges from the glittering confetti of stars. From a distance, it looks like a child's toy. But as you approach, you begin to sense its true dimensions.

This is a titanic maelstrom.

This is The Core.

Star-pilots have long fantasized about what they call The Big Sling—a gravitational slingshot around the black hole at the pit of the Milky Way. The ultimate joyride. As you draw closer, you feel odd sensations in your gut. At first you think it's just nervous anticipation. But suddenly, you realize that something amazing is happening in *Callisto*'s synthetic gravity well. Adjustments are being made.

Meese and Elkins feel it, too. Elkins pats his stomach.

"Tug-of-war," he says. "Feel it?"

"Yeah," says Meese. "What I want to know is, who's winning?"

Elkins says, "The good guys. I hope."

In flight school, they used to talk about a black hole's gravitational tides, how they might stretch you like silly putty. Right now, you feel them pulling you sideways, an odd internal sensation and then, just as quickly, it is gone—pulled back the other way.

Antigravity?

You remember reading about it in the theoretical physics texts of your youth. Negative-energy states—"exotic matter" that exerts negative pressure. A Dutch physicist named Hendrik Casimir was working on antigravity as far back as 1948. Einstein himself posited a kind of antigravity "cosmological constant" that opposes the force of gravity, hence keeping the universe from collapsing in on itself.

Antigravity.

The laws of physics seem to support such a notion. Could the civilization that designed a gravity drive for *Callisto* also have mastered its opposite force?

* * *

What follows is a look at the final flyby sequence. A piloting suggestion: When you get over the black behemoth, switch off your Autopilot and then quickly switch to Slew Control. This eliminates gravity from the situation and lets you cruise around the black hole for a while. I found it most satisfying to slew along the trajectory of the jet of gas spewing up from the north pole, then speed up the Time Scale and gaze back down from above the plane of the galaxy.

We'll end up hovering above the spiral plane of the galaxy.

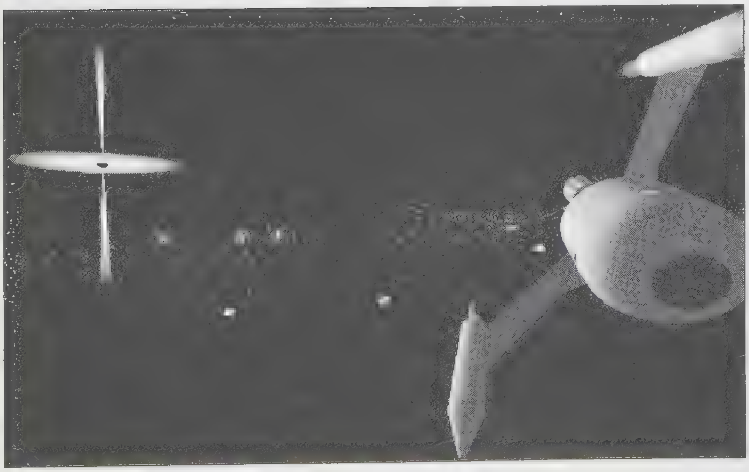


Figure 6-17 *Your first look, Chase view, from about 28 AU. Looks kind of cute from this distance, like a toy top spinning in the blackness.*

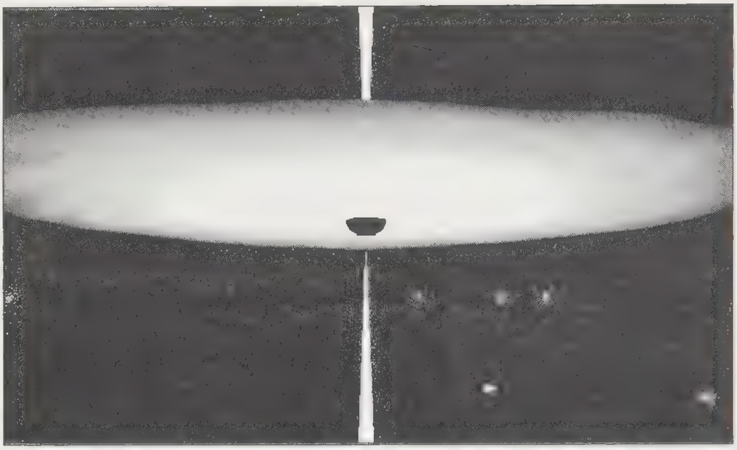
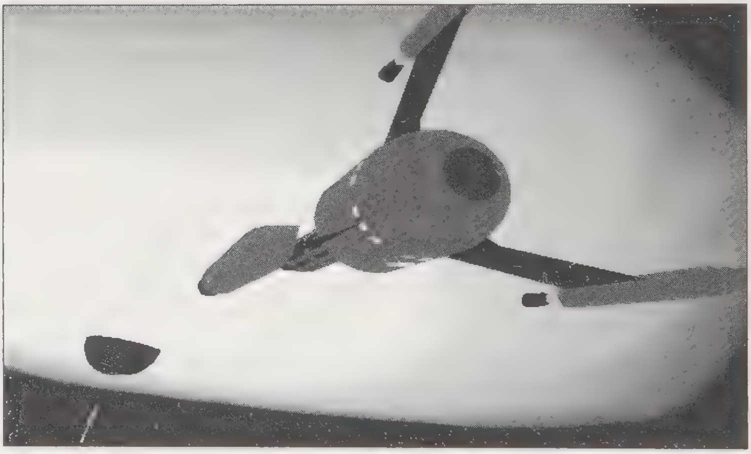


Figure 6-18 *Here's your black hole approach, Cockpit view—note the hot gases spewing in jets from the poles. Are you ready for The Big Sling?*

Figure 6-19 Callisto *is a silhouette against the accretion disk. The black hole itself is thought to be 4 million miles in diameter, which is about 4.5 times the size of the Sun's diameter of 870,000 miles. Yet the relatively tiny hole packs in the mass of a million suns!*



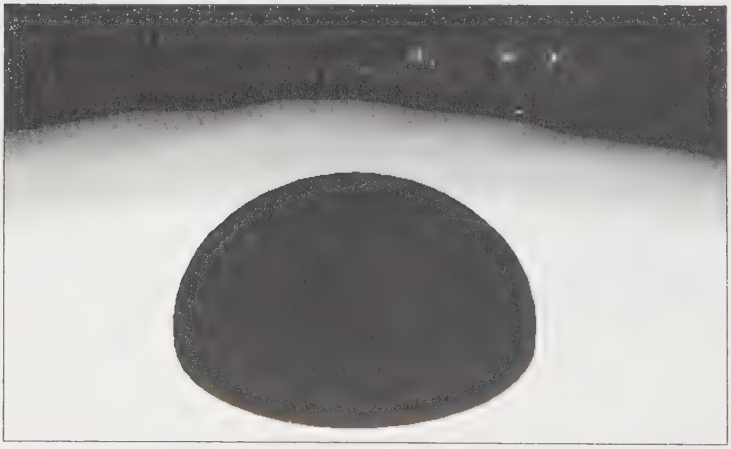


Figure 6-20 *Here's a pass over the voracious monster itself, remnant of a titanic supernova explosion billions of years ago. Its gravity sucks all nearby matter and energy across an "event horizon" which marks the point of no return—not even light can escape its powerful grip. Yet somehow . . .*

Figure 6-21 *. . . you fly past unscathed. Callisto's antigravity displacement somehow keeps you from being torn apart by the tremendous gravitational tides. By the way, here's where it might be fun to switch to Slew Control . . .*

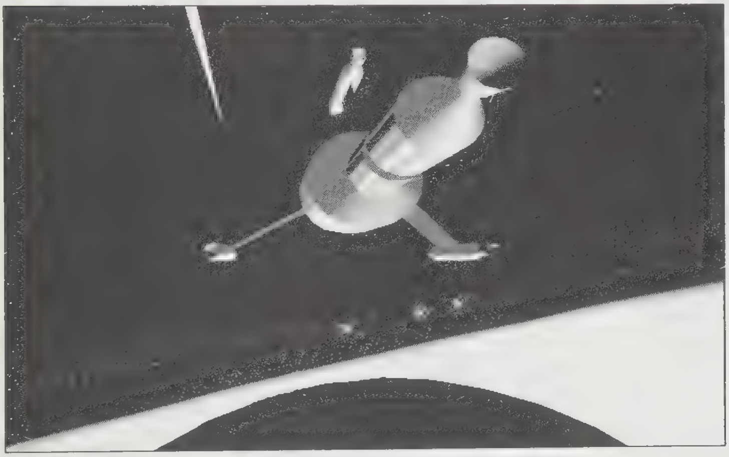


Figure 6-22 *. . . and steer "north" up the polar spine on that plume of jetting gas.*

Appendix A:

Spaceflight Milestones

Date	Spacecraft	Crew	Highlights
10/4/57	Sputnik 1	Unmanned	1st man-made satellite in space
1/31/58	Explorer 1	Unmanned	1st U.S. satellite; discovered Van Allen belt
9/12/59	Luna 2	Unmanned	1st man-made probe to hit Moon
4/12/61	Vostok 1	Gagarin	1st human in space
5/5/61	Mercury 3	Shepard	1st American in space
8/6/61	Vostok 2	Titov	1st full day in space (17 orbits)
2/20/62	Mercury 6	Glenn	1st American in orbit
6/16/63	Vostok 6	Tereshkova	1st woman in space
3/18/65	Voskhod 2	Balyayev, Leonov	1st space walk (Leonov)
3/23/65	Gemini 3	Grissom, Young	1st manned orbital maneuvers
6/3/65	Gemini 4	McDivitt, White	1st American space walk (White)
1/31/66	Luna 9	Unmanned	1st soft landing on Moon
3/16/66	Gemini 8	Armstrong, Scott	1st docking (with unmanned Agena Target Vehicle)
12/21/68	Apollo 8	Borman, Lovell, Anders	1st manned flight around Moon

Date	Spacecraft	Crew	Highlights
7/20/69	Apollo 11	Armstrong, Aldrin, Collins	1st moonwalk (Armstrong)
4/19/71	Salyut 1	Unmanned	1st orbital space station
6/6/71	Soyuz 11	Dobrovolsky, Volkov, Patsayev	Dock with *Salyut 1* station (crew killed during return to Earth)
5/14/73	Skylab 1	Unmanned	1st U.S. space station
7/20/76	Viking 1	Unmanned	1st landing on Mars
2/25/79	Soyuz 32	Lyakhov, Ryumin	Dock with new Salyut 6 station; remain 175 days
3/5/79	Voyager 1	Unmanned	1st flyby of Jupiter & its moons
4/12/81	Columbia	Crippen, Young	1st space shuttle mission
6/18/83	Challenger	Fabian, Hauck, Ride Crippen, Thagard	1st U.S. woman in space (Sally Ride; 2 satellites deployed
1/28/86	Challenger	Scobee, Resnik, McNair, Onizuka, McAuliffe, Smith, Jarvis	Craft explodes shortly after liftoff, killing all 7 astronauts aboard (including schoolteacher Christa Jarvis McAuliffe)

Appendix B:

Quick Keyboard Reference

View Controls

Command	Keystroke
Full Screen View on/off	W
Labels on/off	L
Open View 1 or make it active	1
Open View 2 or make it active	2
Open Map View or make it active	M
Turn on the instrument panel	I
Cycle through view locations (Cockpit, Chase, Assigned)	S
Toggle between Panning and Tracking modes	D
Head-up display on/off	H
Choose map origin	O
Choose reference object	Alt + R
Choose tracking object	T
Cycle through tracking objects	PERIOD (.)/COMMA (,)
Change chase craft distance	Alt + − +
Toggle between relative and absolute chase craft perspective	B
Change Assigned view location	A
Zoom in	PLUS SIGN(+)
Zoom in fast	Shift + +
Zoom out	MINUS SIGN(−)
Zoom out fast	Shift + −

Command	Keystroke
Return to normal magnification	ZERO (0)
Pan up	Alt + UP ARROW (↑)
Pan down	Alt + DOWN ARROW (↓)
Pan left	Alt + LEFT ARROW (←)
Pan right	Alt + RIGHT ARROW (→)
Center view	Alt + KEYPAD 5

Video and Camera Controls

Command	Keystroke
Record video	R
Play video	P
Stop record/play	BACKSLASH (\)
Pause/Unpause	U
Take still photo	PRINT SCREEN

Flight/Slew Controls

Command	Keystroke
Activate slew control	Y
Increase thrust	KEYPAD + or F7
Decrease thrust	KEYPAD - or F6
Full thrust	End or F8
Cut thrust	Home or F5
Fine thrust forward/backward	Shift + KEYPAD + / -
Fine thrust up/down	Page Up / Page Down
Find thrust left/right	Insert / Delete
Cut fine thrust	Home or F5
Pitch up/down	↓ / ↑
Yaw left/right	← / →
Roll left	KEYPAD SLASH (/) or 9
Roll right	KEYPAD ASTERISK (*) or F10
Stop pitch, yaw, roll	KEYPAD 5 or F3
Stop velocity	F4

Other Controls

Command	Keystroke
Toggle between distance/radius & altitude	Alt + S
Accelerate time scale	F1
Decelerate time scale	F2
Set time scale to 1.1 yrs/sec	Shift + F1
Set time scale to 1 sec/sec	Shift + F2
Autopilot on/off	Z
Vehicle transfer	Shift + T
Undock	Shift + U
Space walk or Reboard craft	Shift + W
Deploy or retract lander	Shift + D
Extend or retract landing gear	G
Sound on/off	Q
Calibrate joystick	J
Pause simulation	Pause
Reset simulation	Ctrl + Esc
Exit Space Simulator	Ctrl + Break

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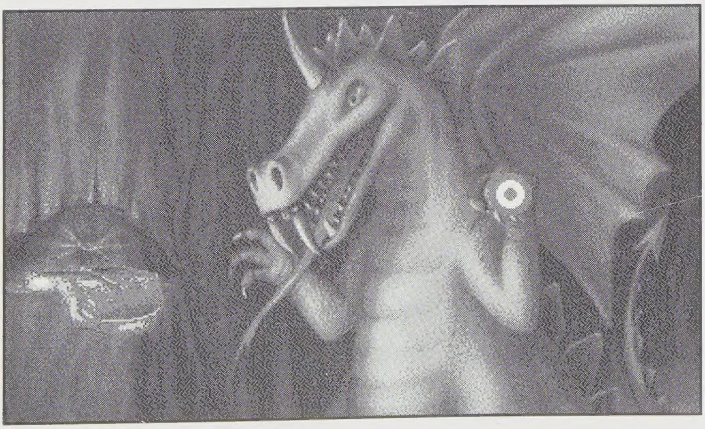

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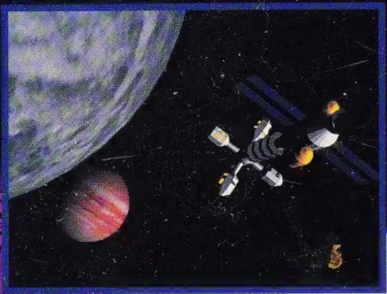

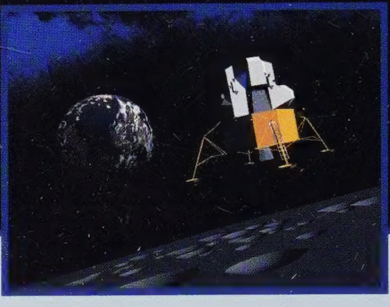

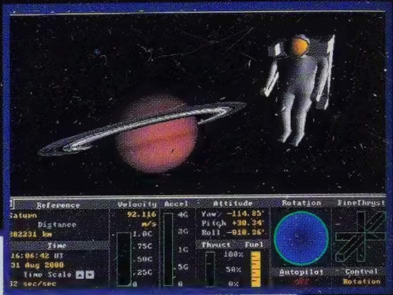
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Rick Barba is a game designer and the author of *Dracula Unleashed: The Official Strategy Guide and Novel, Computer Adventure Games Secrets,* and co-author of *Myst: The Official Strategy Guide* (all from Prima).

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User Level: Ensign to Captain

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